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## **Manufacture and Preparation of Test Specimens for Johnson-Cook Material Characterization**

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## 1.0 INTRODUCTION

As a revision to Contract #W56HZV-05-0721 (WD-FH-0004), this task was added to the current project for the purpose of performing material characterizations and developing Johnson-Cook (J-C) strength and damage constants of friction stir welded (FSW) ballistic joints. These material constants will be used by the government for ballistic, blast and other types of modeling and simulation, and will be included in the Elastic Plastic Impact Code (EPIC) library. This report describes the welding and machining processes used to manufacture the material test specimens used for the J-C material characterization tests and provides the results of metallurgical analysis for the FSW joint of each selected armor material.

At the onset of this project, U.S. Army TARDEC personnel identified six armor materials (See Table 1-1) which were either currently in use or under consideration for future use for ballistic structures and had not undergone FSW joint material strength characterization. Due to budgetary limitations, only three of these materials were selected for J-C analysis: 6061, 5083, and 2139 aluminum alloys. TARDEC wanted high-hardness steel armor to be one of the chosen materials however preliminary FSW tool trials using a tungsten-rhenium tool to weld ½-inch thick plate of this material indicated that excessive tool wear would prohibit its inclusion in this study. Development of FSW weld joints of high-hardness steel armor are continuing at FH-CAT with the goal of including this material in a future J-C material characterization study.

**TABLE 1-1: Ballistic Armor Materials**

Selected for J-C Analysis	<b>1. 6061-T6511 aluminum alloy, Class 1, MIL-DTL-32262</b>
	2. Steel - high-hardness, MIL-DTL-46100E
	<b>3. 5083-H131 aluminum alloy, Class 1, MIL-DTL-46027K</b>
	<b>4. 2139-T8 aluminum alloy, Class 1, MIL-DTL-32341</b>
	5. 2195-T64 aluminum alloy, Class 2, MIL-DTL-32341
	6. Steel – homogeneous, Class 1 or 2, MIL-DTL-12560J

## 2.0 WELD COUPON MANUFACTURING

### 2.1 Material

The 6061 aluminum armor used for this project was manufactured by Kaiser Aluminum (Fairfield, IL) and was delivered as 1-in. x 2-in. x 12-ft. bars (Lot #Z00222015). The full-length bars were then cut into 8-in. lengths<sup>1</sup> using a band saw with cooling fluid.

The 2139 aluminum armor used for this project was manufactured by Alcan Rolled Products (Ravenswood, WV). Due to the limited availability of this experimental armor, it was delivered as three large plates: one 1-in. x 24-in. x 47.5-in. (Lot #820081) and two 1-in. x 48-in. x 48 in. (Lot # 820091). The plates were cut into 2-in. wide bars using a water-jet machine and these bars were then cut into 8-in. lengths using a band saw with cooling fluid. One side of each bar was milled to remove the surface finish left by the water-jet cutting process.

The 5083 aluminum armor used for this project was also manufactured by Alcan and originally delivered to Sunshine Metals (Glenpool, OK) as a 1 1/8-in. x 20-in. x 170-in. plate (Lot #125831). At Sunshine, the plate was then milled to 1.0-in. thick and then sawed into the 12-in. x 156-in. plate that was subsequently delivered to FH-CAT<sup>2</sup>. The plate was then cut into 2-in. x 8-in. segments using a band saw with cooling fluid. One side of each bar was milled to remove the saw marks.

### 2.2 Coupon Production

The weld coupons (Figure 2-1) were all manufactured on the same FH-CAT FSW machine, a Transformation Technologies, Inc. (Elkhart, IN) Model GG1 (Figure 2-2), in single batches for each material. For all three materials, an FSW tool made of H13 tool steel with a scrolled pin and shoulder (See Figure 2-3) was used however the different heat requirements of the materials required that different tool shoulder diameters be used; 50.8-mm for 6061 and 40-mm for 5083 and 2139. The 6061 coupons were

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<sup>1</sup>At the beginning of this expedited project an FSW coupon fixture and machine program that was currently in use at FH-CAT at that time was used for coupon manufacturing.

<sup>2</sup> This 12-in. wide plate was originally ordered as material for ballistic target weldments.

completed on July 11, 2011, the 5083 coupons on August 2, 2011, and the 2139 coupons on November 9, 2011.



**Figure 2-1: 6061 FSW Coupon**



**Figure 2-2: Friction Stir Weld Machine**



**Figure 2-3: FSW Tool (40-mm dia. shown)**

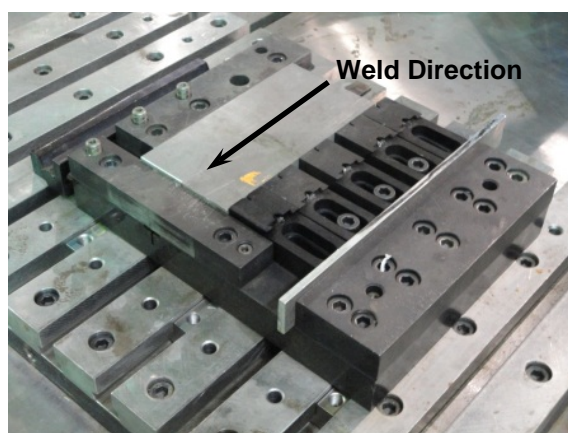
Other than the material-specific welding parameters shown in Table 2-1, the manufacturing of each coupon followed the following process:

1. Clean two material bars with ethyl alcohol and a disposable towel.
2. Blow debris from the fixture using a compressed air nozzle.
3. Place the bars into the fixture (See Figure 2-4), with the square/milled sides at the joint, and tighten the fixture clamps with a hex head torque wrench (25 ft-lbs).
4. Inspect the material installation to confirm proper positioning and fit.
5. Using machine manual mode, lower the spindle so that the FSW tool tip is near the top of the material bars. The exact point of where the tip contacts the material is then found using the manual mode micro adjustment knob.  
Recalibrate the Z-axis positioning to account for fixture height variations caused by heat variations.
6. Initiate the CNC welding program via the machine's operator interface panel.
7. Visually monitor the entire welding cycle.
8. Upon completion of the automated welding cycle, the welded coupon remains in the fixture for 1-2 minutes to allow cooling.
9. Visually inspect the quality of the weld.
10. After the in-fixture cooling period, release the clamps and transfer the coupon to the machine's bed plate to allow it to cool to room temperature.
11. During this cooling step, mark the coupon with a sequential number using a paint pen.
12. Allow the empty fixture to cool before installing the next set of material bars.  
(The cooling period was 10 minutes minimum for the 6061 and 5083 materials.  
Due to high spindle torque during welding of 2139 coupons, the fixture and machine were cooled for a minimum of 30 minutes.)

On several occasions for all material batches, the time span between individual coupon welding was several hours to several days because of personnel and shop work schedules.

**Table 2-1: FSW Coupon Process Parameters**

	<i>Tool Shoulder Dia. (mm)</i>	<i>Rotation (RPM)</i>	<i>Traverse Speed (mm/min)</i>	<i>Axial Force (kN)</i>	<i>Tilt Angle (deg.)</i>	<i>Tool Coolant</i>
6061	50.8	450	150	45	2	no
5083	40.0	300	25	33	3	yes
2139	40.0	250	40	43	3	yes

**Figure 2-4: Coupon Weld Fixture**

As preparation for X-ray inspection of the welds, each coupon was machined to remove the inherent FSW flaws. Both ends of the coupons were removed using a laboratory precision wet saw to remove the weld starts and exit holes and to set the final coupon lengths of 4.5-in. The top surface of each coupon was then milled to remove weld flash.

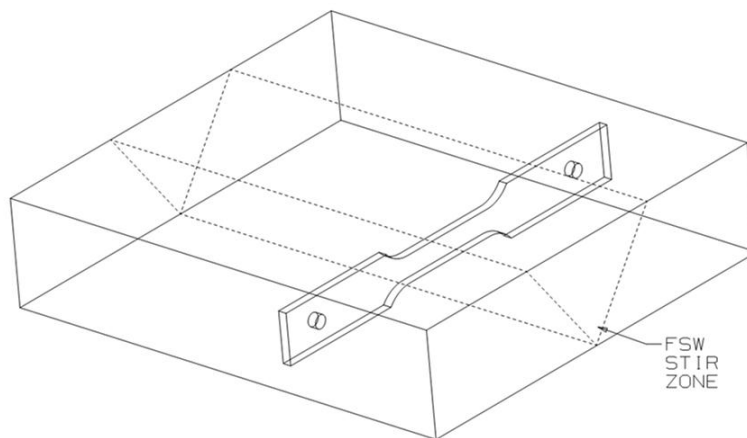
Each material batch of coupons was then X-ray inspected at Magna Chek Inc. (Madison Heights, MI). None of the coupons exhibited any internal flaws.



### 3.0 WELD JOINT METALLURGICAL ANALYSIS

#### 3.1 Sample Preparation

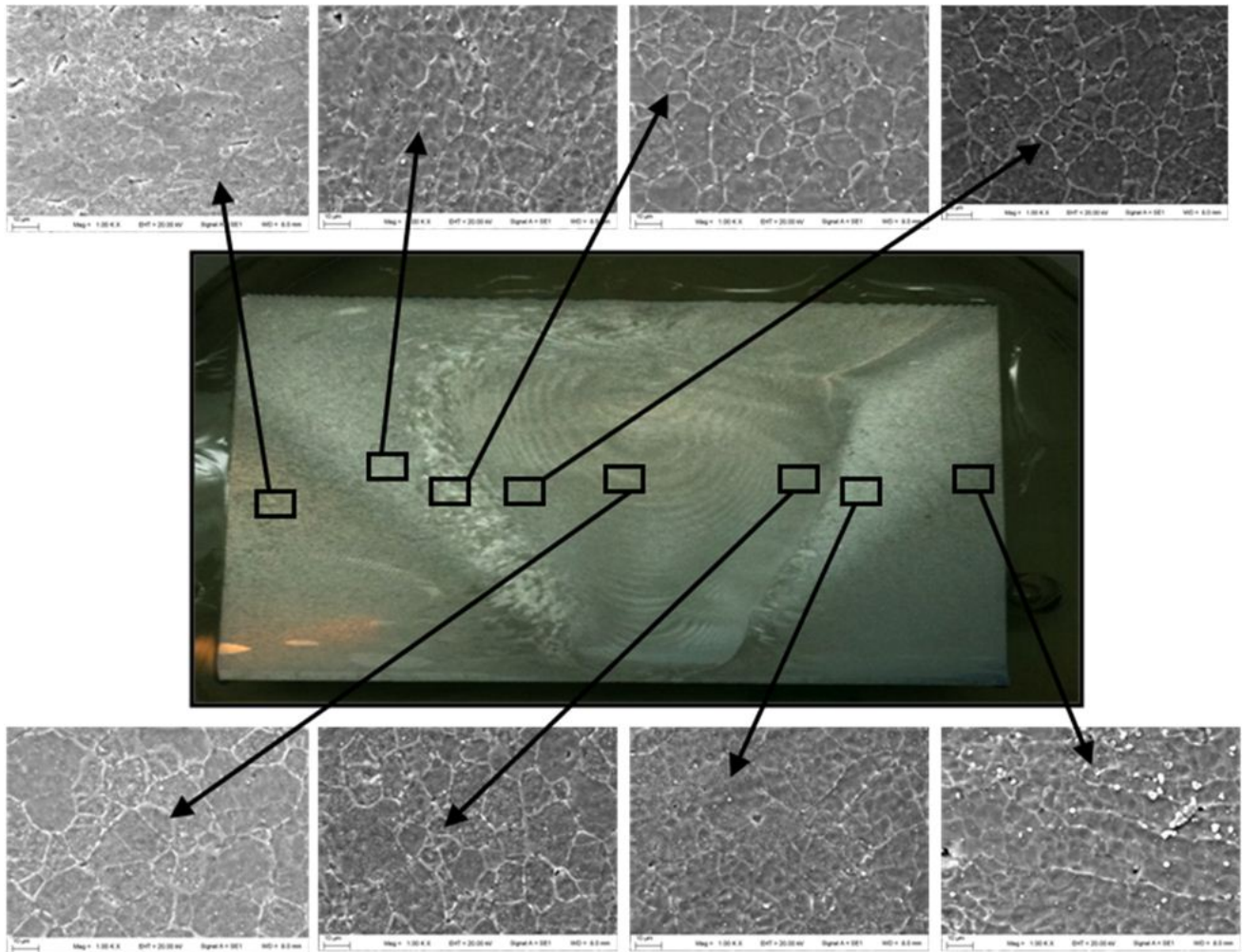
After the material-specific FSW process parameters were optimized (See Appendix A for development process parameters.), a set of coupons was segmented using a laboratory wet saw to provide transverse weld joint samples for hardness evaluation, micrographs, scanning electron microscopy (SEM), electron backscatter diffraction (EBSD), and tensile strength analysis. As required, samples were mounted, polished, and/or chemical etched (Keller's reagent). The transverse tensile test specimens (ASTM E8 – flat, sub-size) were machined and tested at FH-CAT (See Figure 3-1).



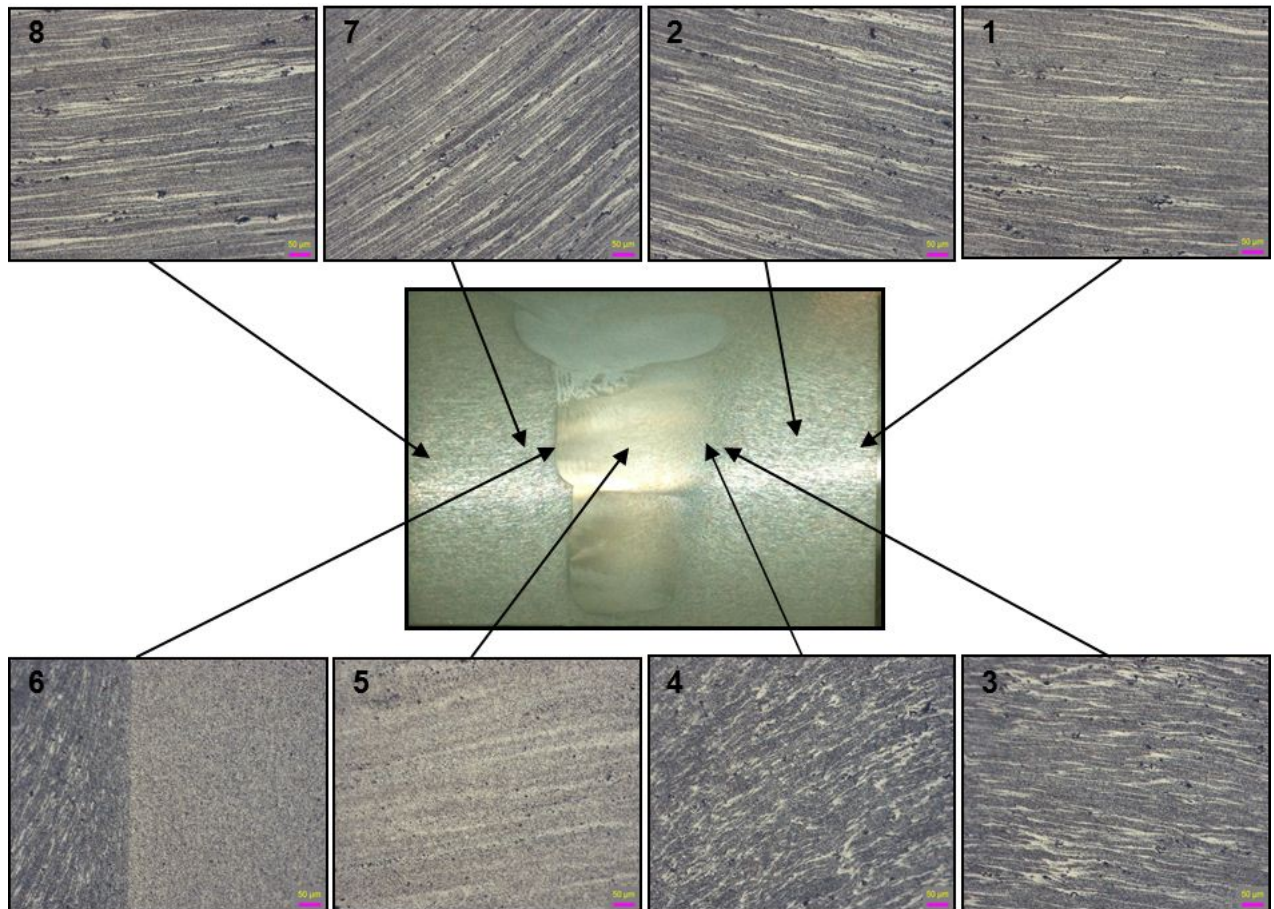
**Figure 3-1: FH-CAT Tensile Test Specimen Location**

#### 3.2 Microstructural Analysis

Microstructural analysis was conducted using a Nikon Eclipse LV150 optical microscope and a Zeiss EVO MA10 SEM. Images were obtained from the optical microscope using a calibrated digital camera, and Scentis software. Optical microscope images were captured at 500x magnification and SEM images were captured at 500x and 1000x magnifications. Figures 3-2, 3-3 and 3-4 show the microscopic results for Al 6061, Al 5083, and Al 2139 respectively.

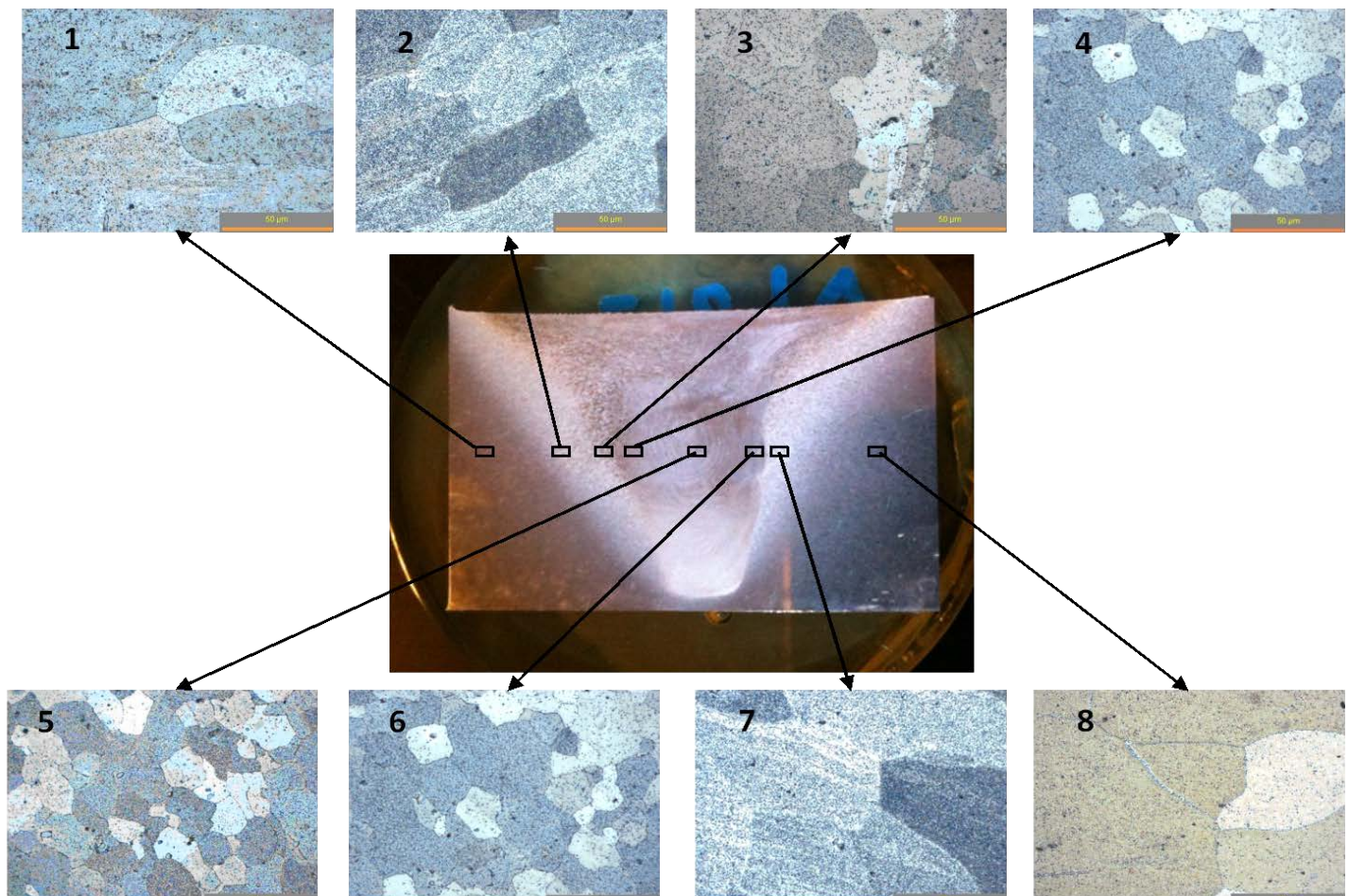


**Figure 3-2: Microscopic Views of 6061 FSW Joint**



**Figure 3-3: Microscopic Views of 5083 FSW Joint.**

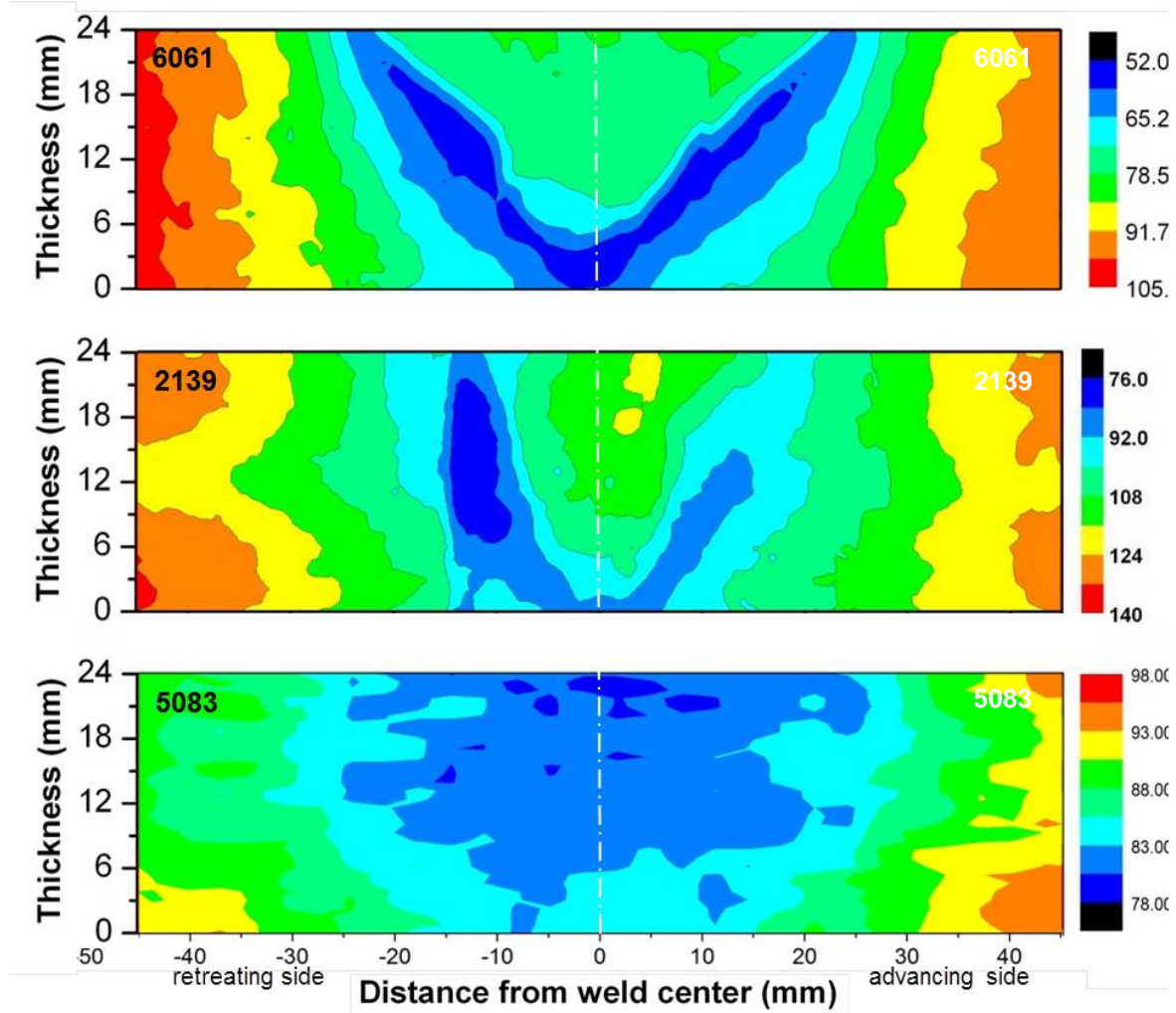




**Figure 3-4: Microscopic Views of 2139 FSW Joint.**

### 3.3 Microhardness

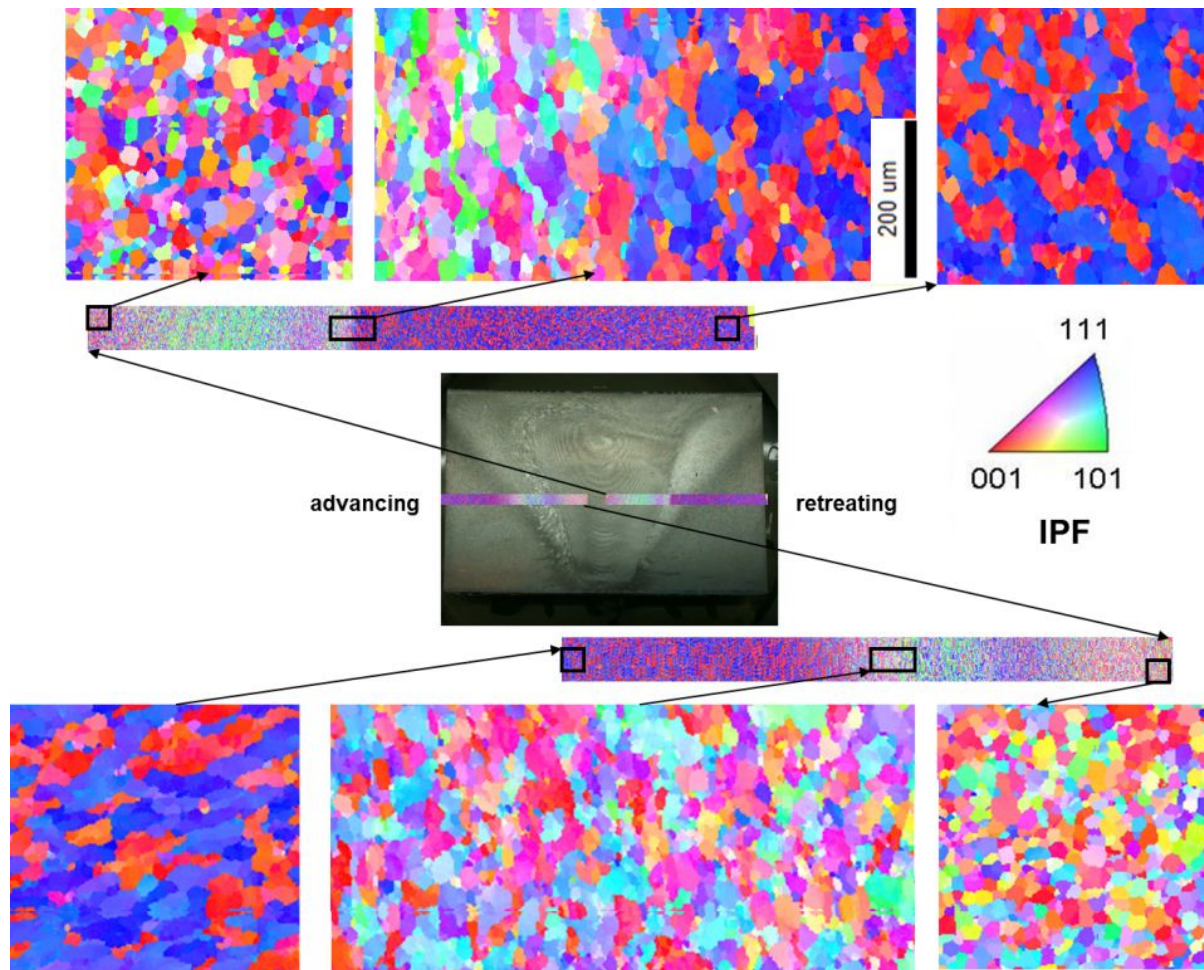
Microhardness charts were created using a Leco LM100AT hardness tester. Figure 3-5 compares the microhardness charts for the 6061, 5083, and 2139 FSW weld joints.



**Figure 3-5 : FSW Joint Micro-Hardness (HV)**

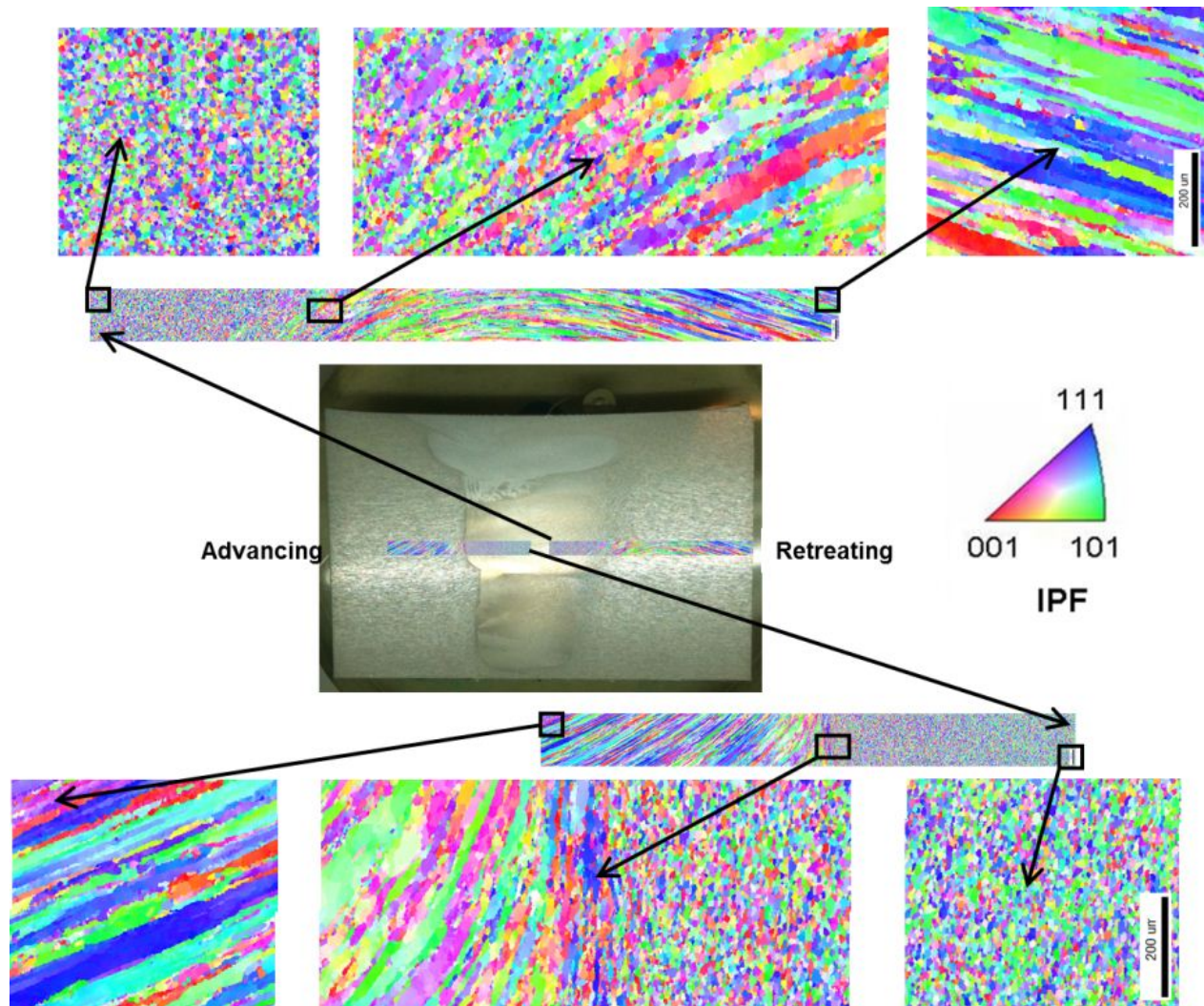
### 3.4 Electron Backscatter Diffraction

Further definition of the metallurgic grain structure across the weld joint was conducted using EBSD. Prepared FSW joint samples were analyzed with a Hikari/EDAX backscatter detection system mounted to a Zeiss EVO MA10 SEM. Figures 3-6, 3-7, and 3-8 show the EBSD results.

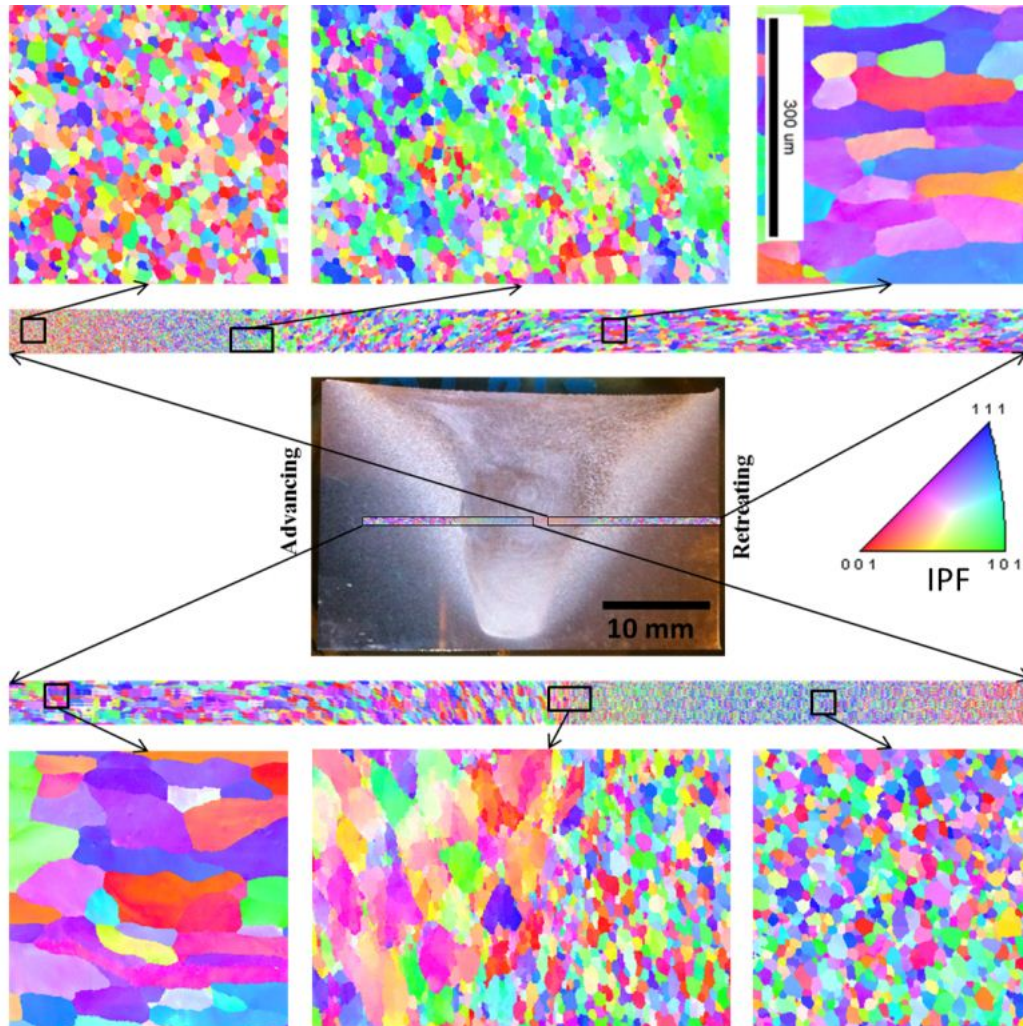


**Figure 3-6: EBSD of 6061 FSW Joint**





**Figure 3-7: EBSD of 5083 FSW Joint**



**Figure 3-8: EBSD of 2139 FSW Joint**

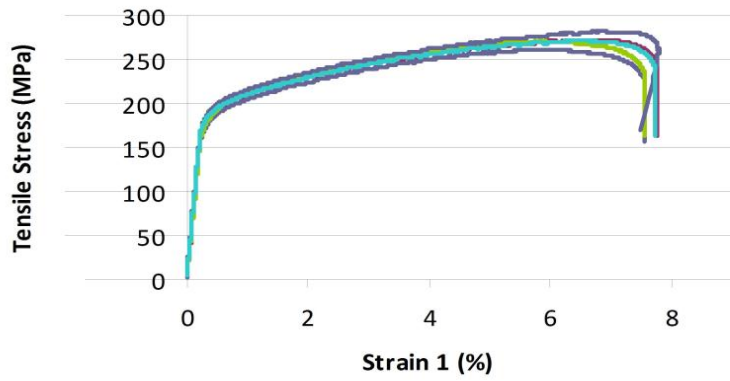


### 3.5 Tensile Strength

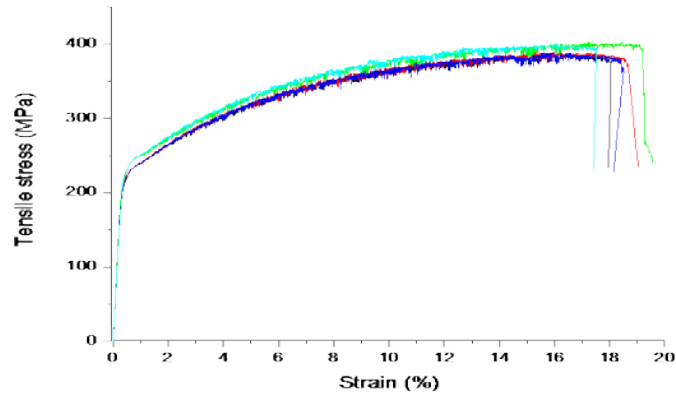
Tensile tests were conducted using an Instron Model 5982 universal testing machine with a strain rate of 1 mm/min. The force was measured using a 100 kN load cell, and elongation was measured using a 1-in. length extensometer. Table 3-1 compares the strength test results for all three FSW materials with their respective base materials. Figures 3-9, 3-10, and 3-11 show the stress vs. strain relationships of the FSW joints.

**Table 3-1 : Tensile Test Results**

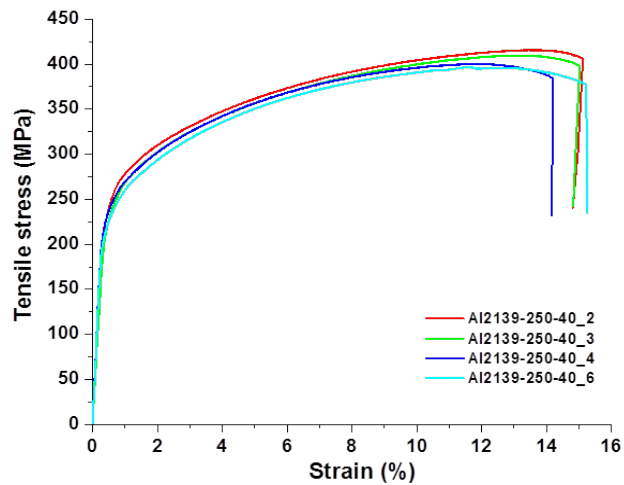
	<i>Yield Strength (MPa)</i>	<i>Ultimate Yield (MPa)</i>	<i>% Elongation</i>
<b>6061 FSW</b>	194	270	7.06%
<b>6061 Base</b>	507	576	12%
<b>% Change</b>	-61.7%	-53.1%	-41.2%
<b>5083 FSW</b>	229	394	18.4%
<b>5083 Base</b>	333	442	19%
<b>% Change</b>	-31.2%	-10.9%	-3.2%
<b>2139 FSW</b>	235	405	14.9%
<b>2139 Base</b>	475	500	13.1%
<b>% Change</b>	-50.5%	-19.0%	13.7%



**Figure 3-9: 6061 FSW Stress vs. Strain**



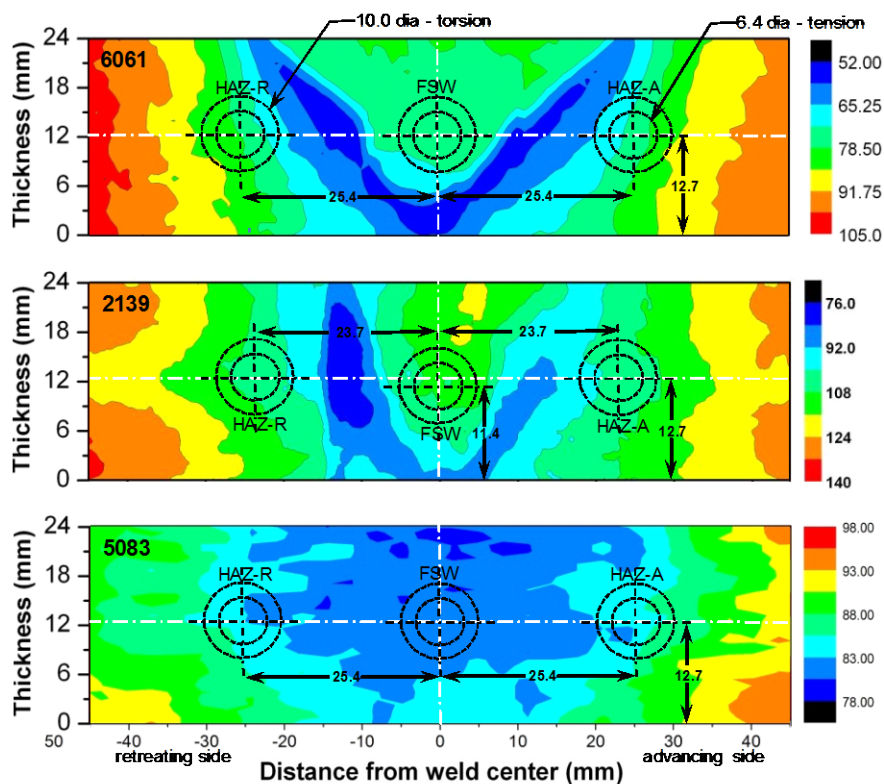
**Figure 3-10: 5083 FSW Stress vs. Strain**



**Figure 3-11: 2139 FSW Stress vs. Strain**

### 3.5 J-C Test Specimen Location

SWRI selected the centerline positions of the final specimens using the coupon transverse micro-hardness chart (See Figure 3-12) and macro-etch sample for each material. While the weakest part of an FSW joint is typically the thermo-mechanically affected zone (TMAZ) where the softest material is found, commonality with a previous FSW joint characterization study<sup>3</sup> was the driving factor for the positions selected for this project. For only the 2139 FSW zone material, the horizontal centerline of the specimen location was slightly lower (1.3-mm) than all other locations to avoid a small area of relatively harder material in the upper, advancing side of the FSW zone.

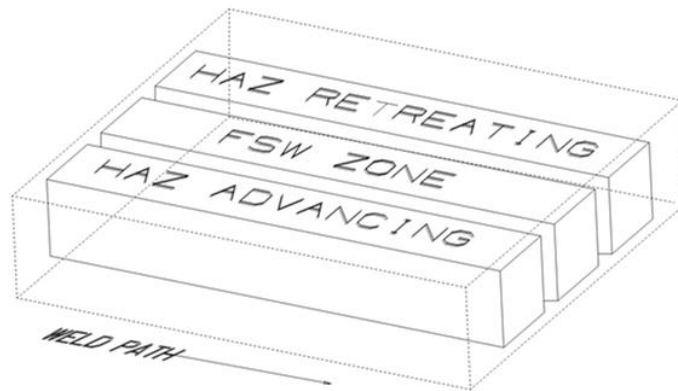


**Figure 3-12: Specimen Locations**

<sup>3</sup> TARDEC Report 18.12544/026, *Mechanical Characterization of Friction Stir Welded Aluminum 5059-H131 (Weld and Heat Affected Zone) for Determination of Johnson-Cook Constitutive Constants*, Sep 2010, Southwest Research Institute, San Antonio, TX

#### 4.0 FINAL SPECIMEN MACHINING

After returning from X-ray inspection, three specimen bars were longitudinally extracted from each FSW coupon; FSW zone, HAZ advancing side, and HAZ retreating side (See Figure 4-1).



**Figure 4-1: Specimen Bar Coupon Locations**

To duplicate previous J-C strength and damage studies of armor material conducted at SWRI, several different specimen configurations were required from each of the coupon specimen positions (See Table 4-1). See Appendix B for the specimen design prints and Appendix C for FH-CAT machining process descriptions.

For all of the specimen bars of the 6061 and 5083 material sets, one end was machined using a Cincinnati 630XT CNC machining center to a diameter of 0.75-in. (0.80-in. for B and E Notch Tension specimen bars) to aid subsequent processes. One end of  $\frac{3}{4}$ -13 UNC-2A threads for the B and E Notch Tension specimen bars were also machined at this operation. Throughout the FH-CAT manufacturing process, material coupons, specimen bars, and specimens were segregated into separate bins, bags, and/or laser marked between process steps. Each specimen was individually bagged for shipping to SWRI.

6061 and 5083 base material .250 Tension specimens were initially produced as a machining process trial and then provided to SWRI for inspection and approval. With their approval, “production” manufacturing of the FSW test specimens began.

**Table 4-1: J-C Test Specimens**

Material Location	Test Type	Specimen Type	SWRI Dwg. No.	Qty
<b>FSW ZONE</b>	Quasistatic Tension	Threaded cylind. tensile	18-01147-510-5A	8
	B-Notched Tension	Threaded cylind. tensile	18-01147-510-3	4
	E-Notched Tension	Threaded cylind. tensile	18-01147-510-4	4
	SHPB Tension	Threaded cylind. tensile	"SHPB Tensile"	8
	SHPB Compression	Cylinder L/D=2	18-01147-510-6	16
	Taylor Anvil	Cylinder L/D = 5	"T.A.I.T Specimen" 10-11-2005	10
	Torsion	Hollow, Hex head	"Torsion Specimen Subsize" 07-21-2005	8
<b>HAZ ADVANCE</b>	Quasistatic Tension	Threaded cylind. tensile	18-01147-510-5A	4
	Taylor Anvil	Cylinder L/D = 5	"T.A.I.T Specimen" 10-11-2005	10
<b>HAZ RETREAT</b>	Quasistatic Tension	Threaded cylind. tensile	18-01147-510-5A	4
	Taylor Anvil	Cylinder L/D = 5	"T.A.I.T Specimen" 10-11-2005	10
<b>BASE</b>	Quasistatic Tension	Threaded cylind. tensile	18-01147-510-5A	8

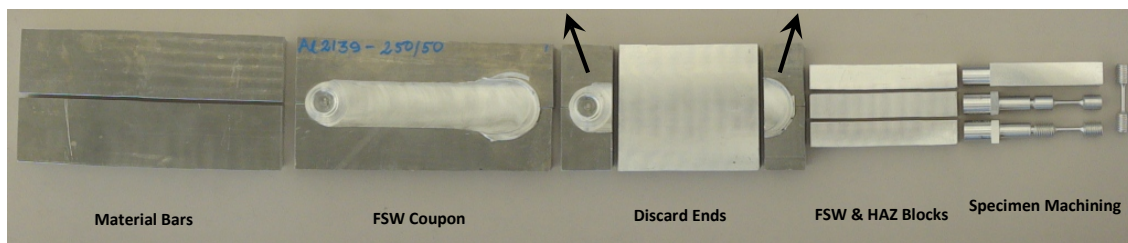
The Quasistatic Tension, SHPB Tension, SHPB Compression, and Taylor Anvil Impact Test specimens of the 6061 and 5083 materials were machined at FH-CAT. Due to machine resource limitations at FH-CAT, the machining of the 6061 and 5083 B-Notch Tension, E-Notch Tension, and Sub-size Torsion specimens and all of the 2139 specimens was done by the SWRI machine shop using FSW material blanks provided by FH-CAT.

The FH-CAT Quasistatic and SHPB Tension specimens were turned to final shape and threaded using a Mazak 100-III3 CNC machining center yielding one specimen per material blank. These specimens were then manually polished using a bench grinder with a 6-in. dia. sewn cotton buffing wheel. For the final operation, each tension

specimen was inserted into a ½-in. inside diameter plastic tube to protect the surface finish and then cut to final length using the Mazak 100. Figure 4-2 depicts the complete manufacturing process, material bars thru final machining, for the tension specimens.

The Taylor Anvil Impact Test (TAIT) specimen blanks were turned to 0.625-in. diameter using the Mazak 100 and subsequently turned to final diameter and rough length using a Hardinge Conquest T42 CNC lathe. This process yielded three specimens per material blank. The TAIT specimens were then milled to final length using a Cincinnati VMC500 CNC machining center.

The SHPB Compression specimens were turned to final diameter and rough length (four per blank) using the Hardinge CNC lathe and were then milled to final length using the Cincinnati VMC500.



**Figure 4-2: Specimen Manufacturing - Material Stock Thru Final Machining**

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## **Appendix A**

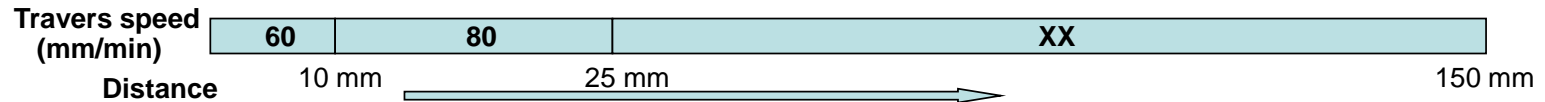
FSW Process Parameter Development

UNCLASSIFIED

**DOE for FSP/FSW of 6061-T651 Al****DOE 014****Operator:****Date: 04/13/11****Substrate Material: 6061-T651 Al, 1" thick plate, 8 " × 2 " in size**

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	38	25		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	800	35	20	- 24	- 25



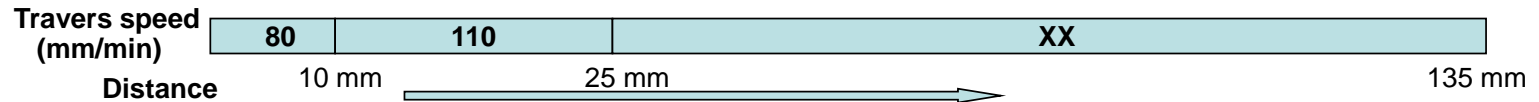
Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1(9)	300	100	35	34	2		
2(10)	300	120	35	36	2		
3(11)	300	140	35	38	2		
4(7)	400	120	35	25	2		
5(8)	400	150	35	28	2		



**DOE for FSP/FSW of 6061-T651 Al****DOE 015****Operator:****Date: 04/28/11****Substrate Material: 6061-T651 Al, 1" thick plate, 10 " × 2 " in size**

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	50.8	24		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	800	45	20	- 24.2	- 24.2

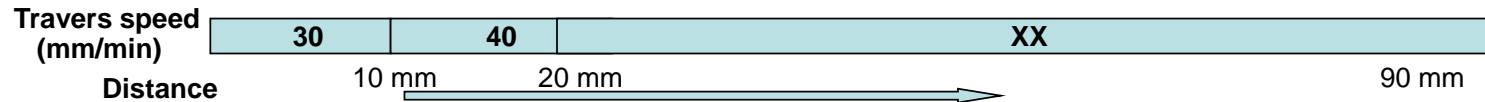


Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1(1)	450	140	45	48	2	No defect	
2(2)	450	160	45	50	2	No defect	
3	450	180	45		2		
4(3)	500	140	45	48	2	No defect	
5(4)	500	160	45	51	2	No defect	
6	500	180	45		2		
7	550	140	45		2		
8	550	160	45		2		
9	550	180	45		2		

**DOE for FSW of Al 5083-H131****DOE 017****Operator:****Date: 06/08/11****Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size**

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.0	- 24.17

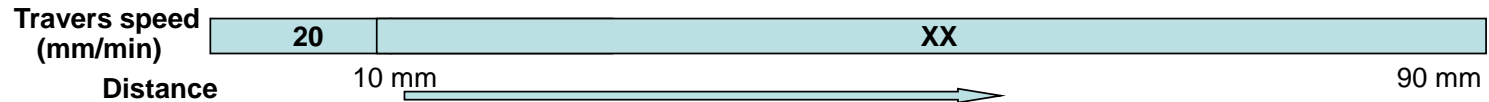


Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	300	36	60	32-34	2		
2	300	45	60	32-34	2		
3	300	54	60	35-37	2		
4	350	36	60	30-35	2		
5	350	45	60	31-33	2		
6	350	54	60	39-41	2		
7	400	36	60	33-35	2		
8	400	45	60	38-40	2		
9	400	54	60	40-42	2		

**DOE for FSW of Al 5083-H131****DOE 019****Operator:****Date: 06/22/11****Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size**

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.0	- 24.17

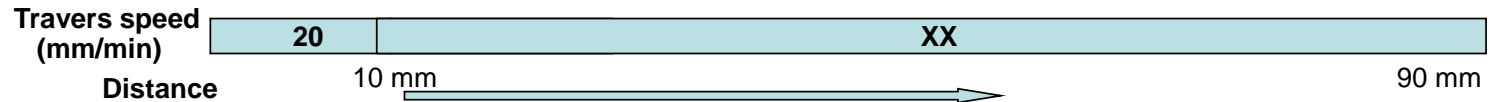


Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	300	20	60	28-31	2		
2	300	30	60	28-29	2		
3	300	40	60	28-29	2		
4	350	20	60	28-30	2		
5	350	30	60	28-29	2		
6	350	40	60	28-29	2		
7	400	20	60	27-33	2		
8	400	30	60	28-29	2		
9	400	40	60	30-31	2		

**DOE for FSW of Al 5083-H131****DOE 020****Operator:****Date: 06/23/11****Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size**

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.0	- 24.17

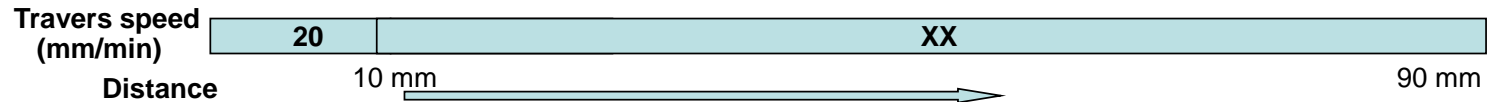


Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	300	20	60		3		
2	300	30	60		3		
3	300	40	60		3		
4	350	20	60		3		
5	350	30	60		3		
6	350	40	60		3		
7	400	20	60		3		
8	400	30	60		3		
9	400	40	60		3		

**DOE for FSW of Al 5083-H131****DOE 021****Operator:****Date: 06/24/11****Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size**

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.0	- 24.17



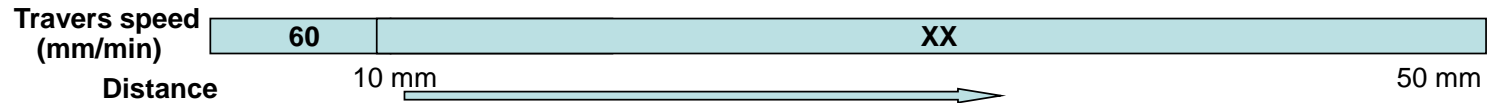
Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	250	20	60	33	3		No defect
2	250	25	60	33	3		No defect
3	250	30	60	33	3		No defect
4	300	20	60	34	3		No defect
5	300	25	60	33	3	Best Parameter	No defect
6	300	30	60	33	3		No defect
7	350	20	60	30	3		No defect
8	350	25	60	31	3		No defect
9	350	30	60	33	3		No defect

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**DOE for FSW of Al 2139-T8****DOE 022****Operator:****Date: 09/26/11****Substrate Material: Al 2139-T8, 1" thick plate, 8 " × 2 " in size**

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	50.8	24.05		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.05	- 24.05



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	400	100	50	63	2		
2	400	70	60	69	2		
3	350	100	60	87	2		
4							
5							
6							
7							
8							
9							

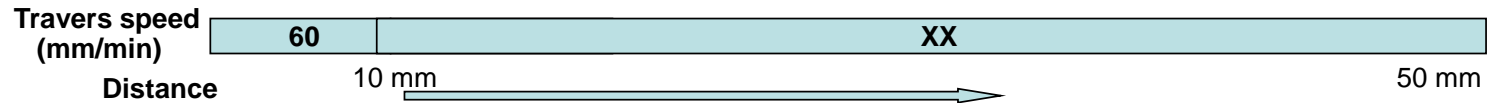
UNCLASSIFIED

UNCLASSIFIED

**DOE for FSW of Al 2139-T8****DOE 023****Operator:****Date: 09/26/11****Substrate Material: Al 2139-T8, 1" thick plate, 8 " × 2 " in size**

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.17	- 24.17



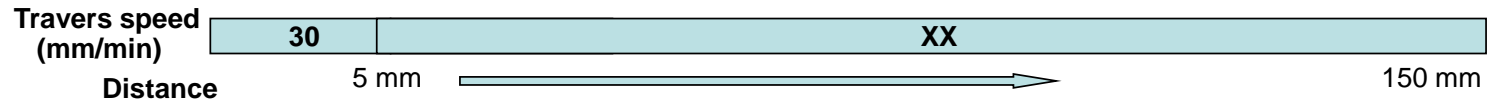
Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	350	80	60	58	3	Wormhole	
2	300	60	60	57	3	Wormhole	
3	300	80	60	59	3	Wormhole	
4	250	60	60	50	3	Wormhole	
5	250	40	60	45	3	No defect	

UNCLASSIFIED

**DOE for FSW of Al 2139-T8****DOE 024****Operator:****Date: 09/28/11****Substrate Material: Al 2139-T8, 1" thick plate, 8 " × 2 " in size**

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.33		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.35	- 24.35



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	250	30	60	39-43	3		No defect
2	250	40	60	40-45	3	Best Parameters	No defect
3	250	50	60	42-48	3		No defect



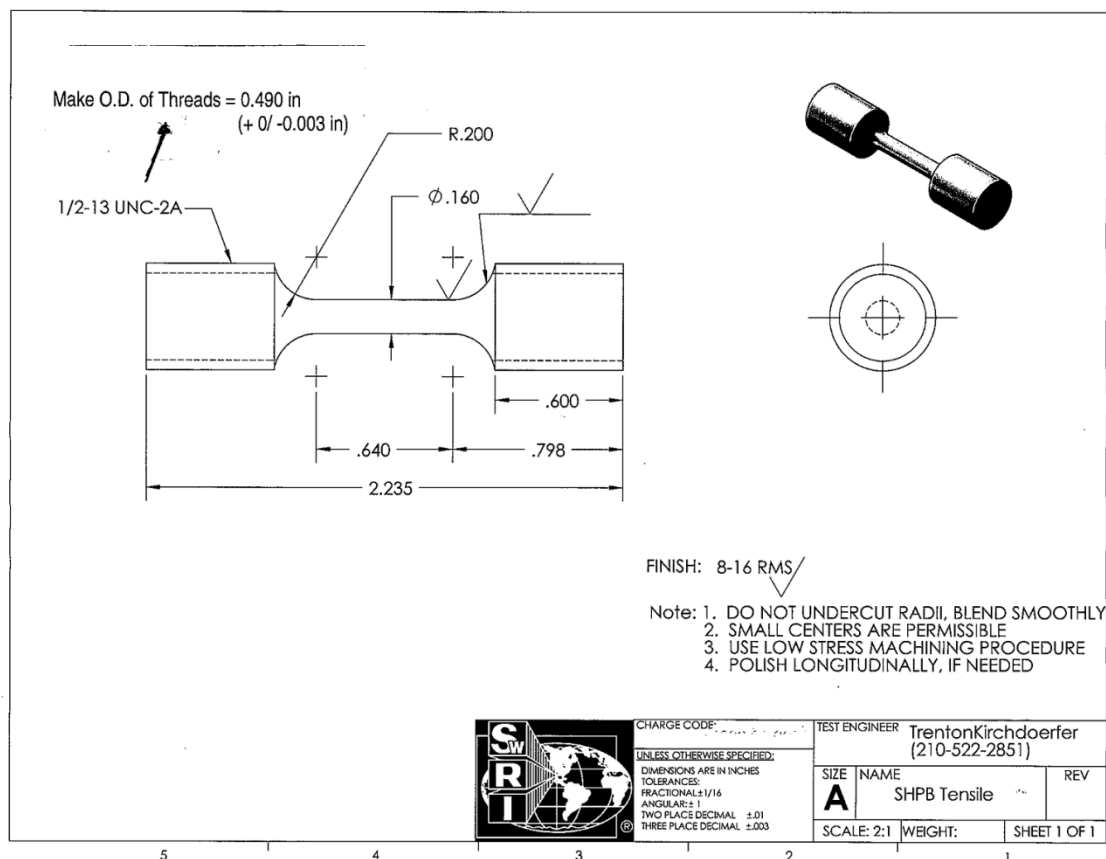
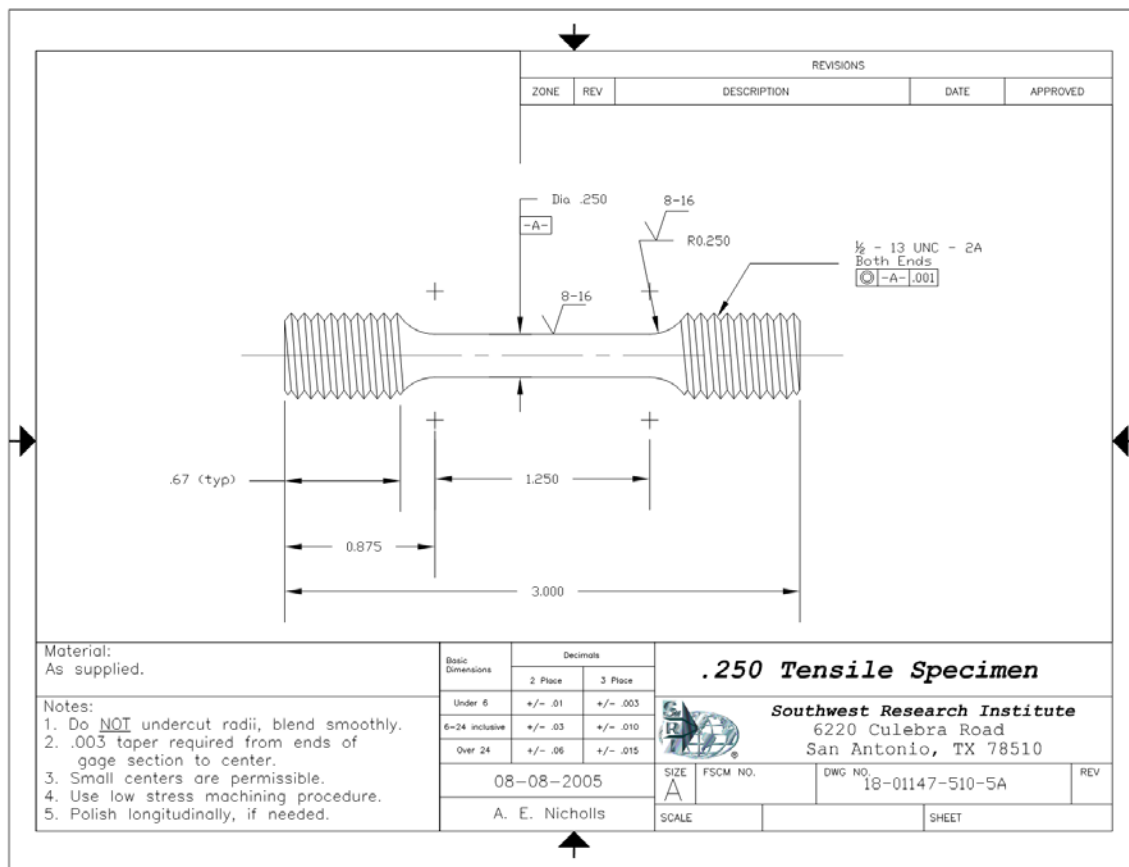
UNCLASSIFIED

## Appendix B

### **J-C Test Specimen Prints**

B-1

UNCLASSIFIED



LTR	DESCRIPTION	DATE	APPROVED

NOTE: USE LOW STRESS MACHINING PROCEDURE

FIND NO.	QTY REQ.	SIZE	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST					
MATERIAL	BASIC DIMENSIONS	DETAILS	FIND NO.	CONTRACT	SOUTHWEST RESEARCH INSTITUTE
	UNDER 8	2 PLACE	3 PLACE	1-11-2000	A. NAGY
	8-24 INCL	2 .01	2 .003	2 1/32	OKD
	OVER 24	2 .03	2 .018	2 1/16	MECH
	ANGLES	2 6° 30'	2 1° 0'	2 1/8"	ELECT

USED ON	QTY. REQD.	DRAWING NO.	SCALE	SHEET
		18-01147-510-6		

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

T.A.I.T Specimen

Material:	Basic Dimensions	Decimals	SIZE	FSCM NO.	DWG NO.	REV
	Under 8	+/- .01	+/- .003			
	8-24 Inclusive	+/- .03	+/- .010			
	Over 24	+/- .08	+/- .018			

Notes:	A. E. Nicholls	SCALE	SHEET

8-16

100 R

3/4 - 10 UNC - 2A  
BOTH ENDS

0.600

0.300

1.13

2.00

4.00

0.200

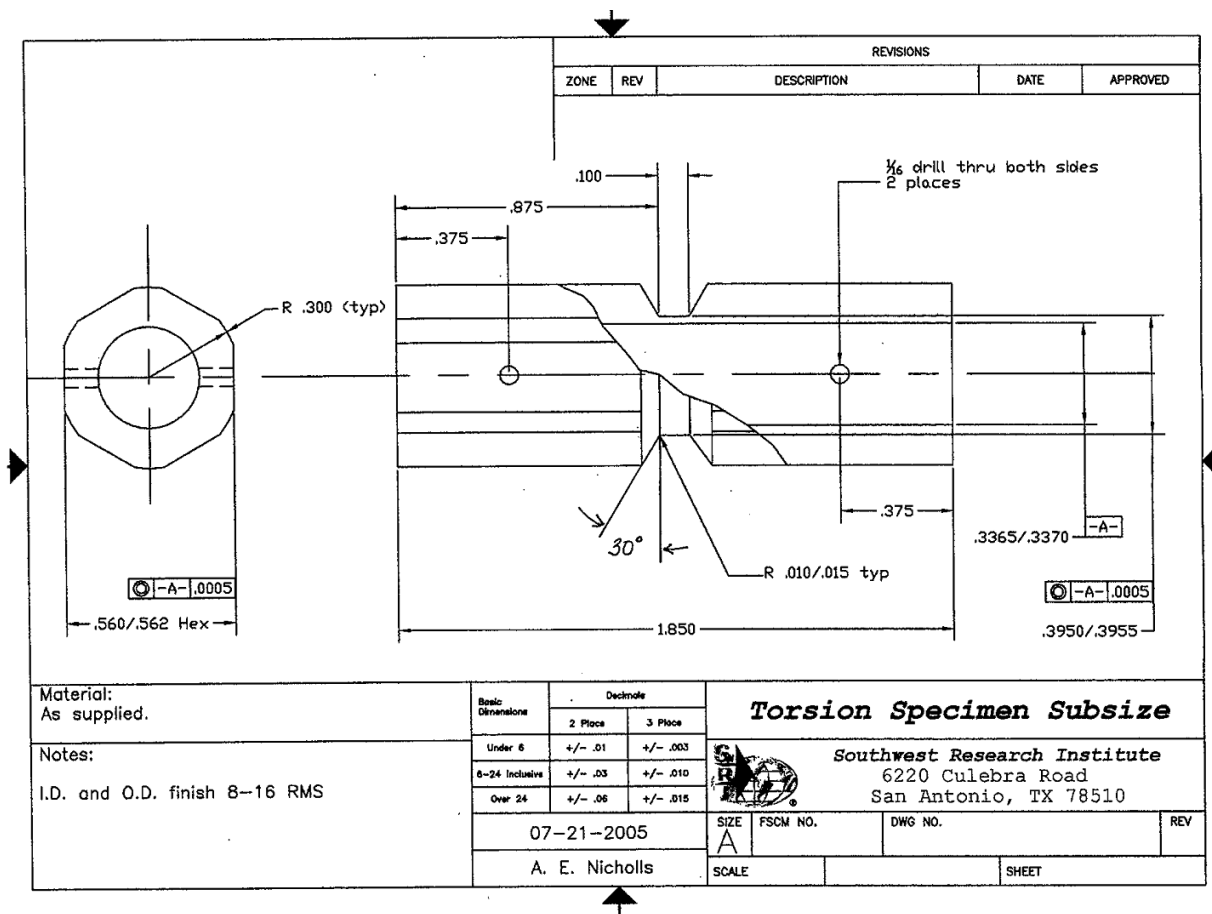
LENGTH WAS 5.50

8-18  
.250 R  
Ø .600 TYP  
-A-  
Ø .300  
3/4 - 10 UNC - 2A BOTH ENDS  
Ø -A- .001  
1.13  
1.15  
2.00  
4.00

NOTE: 1. SMALL CENTERS ARE PERMISSIBLE  
2. USE LOW STRESS MACHINING PROCEDURE

E: 12000104RPA1ENOTCH

UNCLASSIFIED



UNCLASSIFIED

## Appendix C

### **FH-CAT Machining Processes**

**Focus: HOPE Process routing/Shop traveler**

Customer: <b>Southwest Research Institute</b>		
Street Address:		
City State Zip:		
Stock: <b>4 x 4 1/2 x 1 coupon (8)</b>		
Part Number:		
Description: <b>Johnson-Cook Test Specimen Blocks 6061/5083</b>		
Revision:		
Op No	Labor Code	Operation Description
10	Height Gage & Scribe	Find, and scribe weld centerline on ends of block.
20	Mill	Mill TOP to 0.875
30	Laser Marker	Mark TOP face of coupon per print (MMMM-X-TOP-NN, Where X=A,W, or R)
40	Mill	Mill BOTTOM to 0.750 thick
50	Mill	Mill coupon to 1.38 from weld centerline (retreating side)
60	Band Saw	Saw Block W .475 (minimum) from weld centerline (retreating side) SET ASIDE CUT OFF BLOCK "R"
70	Mill	Mill coupon to .375 from weld centerline (retreating side)
80	Mill	Flip around (TOP still facing up) and mill coupon to 1.75
90	Band Saw	Saw block at 'A' to .850 and remaining strip 'W' at .900 ref
100	Mill	Mill 'W' to .750 (from saw cut side)
110	Mill	Mill R to .750 (From saw cut side)
120	Mill	Mill A to .750 (from saw cut side)
130		Measurement of finished blocks, per inspection check sheet

4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

C

C

RETREATING SIDE  
(CLAMP MARKS)

SCRIBED WELD  
CENTELINE  
BOTH ENDS

3.70

4.50 REF

.90 REF

A

B

B


A

A

DECIMALS		TOLERANCES	
1 PLACE.....	±.045	ANGULAR ±0° 30'	
2 PLACE.....	±.030	FRACTIONS ±1/16	
3 PLACE.....	±.015		
4 PLACE.....	±.005		

UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL: 5083 ALUMINUM

IP10  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE											
USAGE:				FOCUS: ROPE			MANUFACTURING						
ARMY - FSP				THIRD ANGLE PROJECTION									
		PART NAME J C TESTING STRIPS											
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP10-DWG									
CHECKED BY R.Z.		DATE 9/23/11		PART NO.									
RELEASED BY		UNITS INCHES		SCALE N/A		SIZE C		DWG LEVEL 100		REV		SHEET 1 of 1	

4

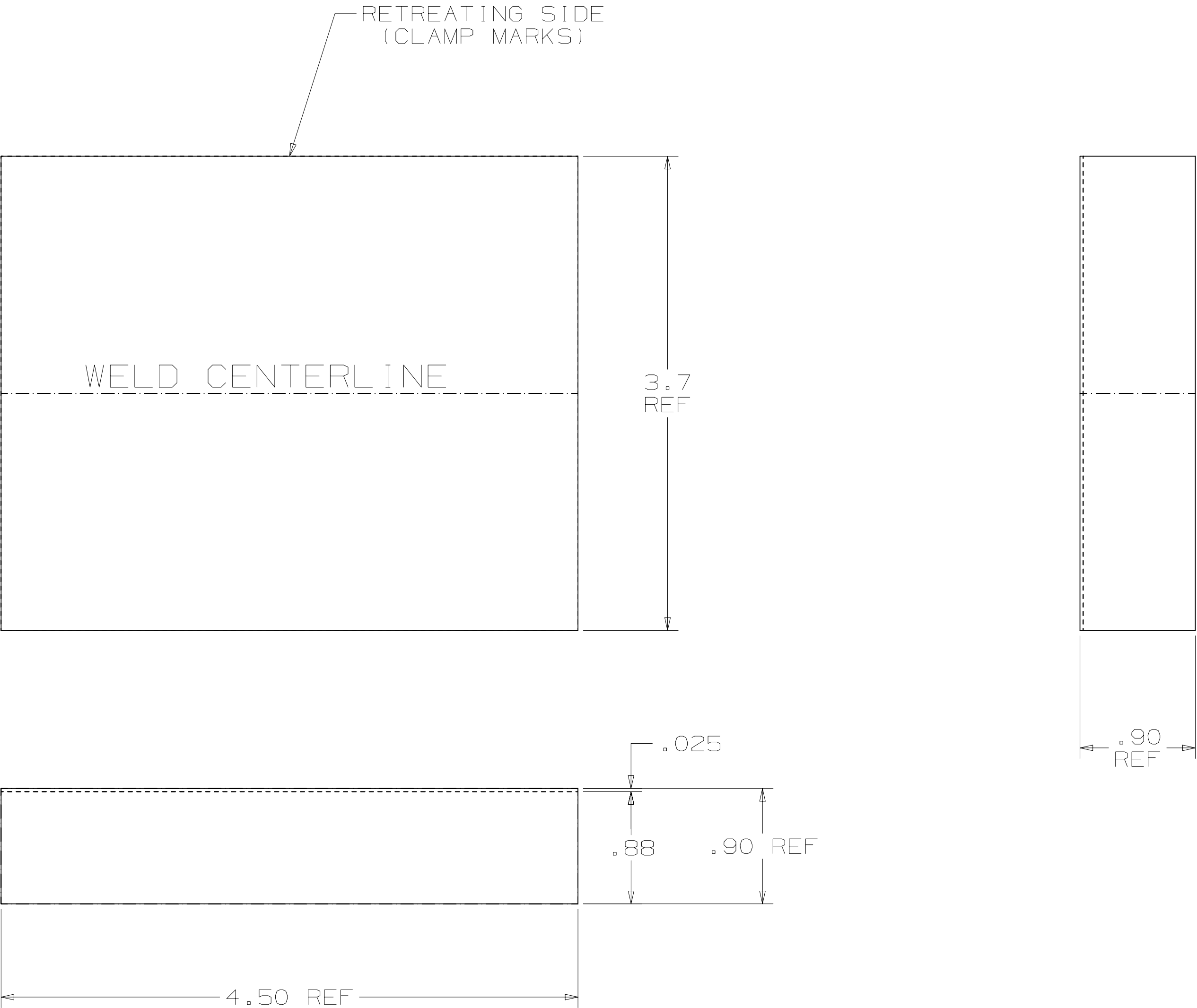
3

2

1



1							
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION		CN#
							CHG
							APV



DECIMALS TOLERANCES

1 PLACE.....	±.045
2 PLACE.....	±.030
3 PLACE.....	±.015
4 PLACE.....	±.005

UNLESS OTHERWISE SPECIFIED

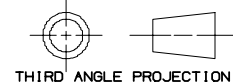
BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

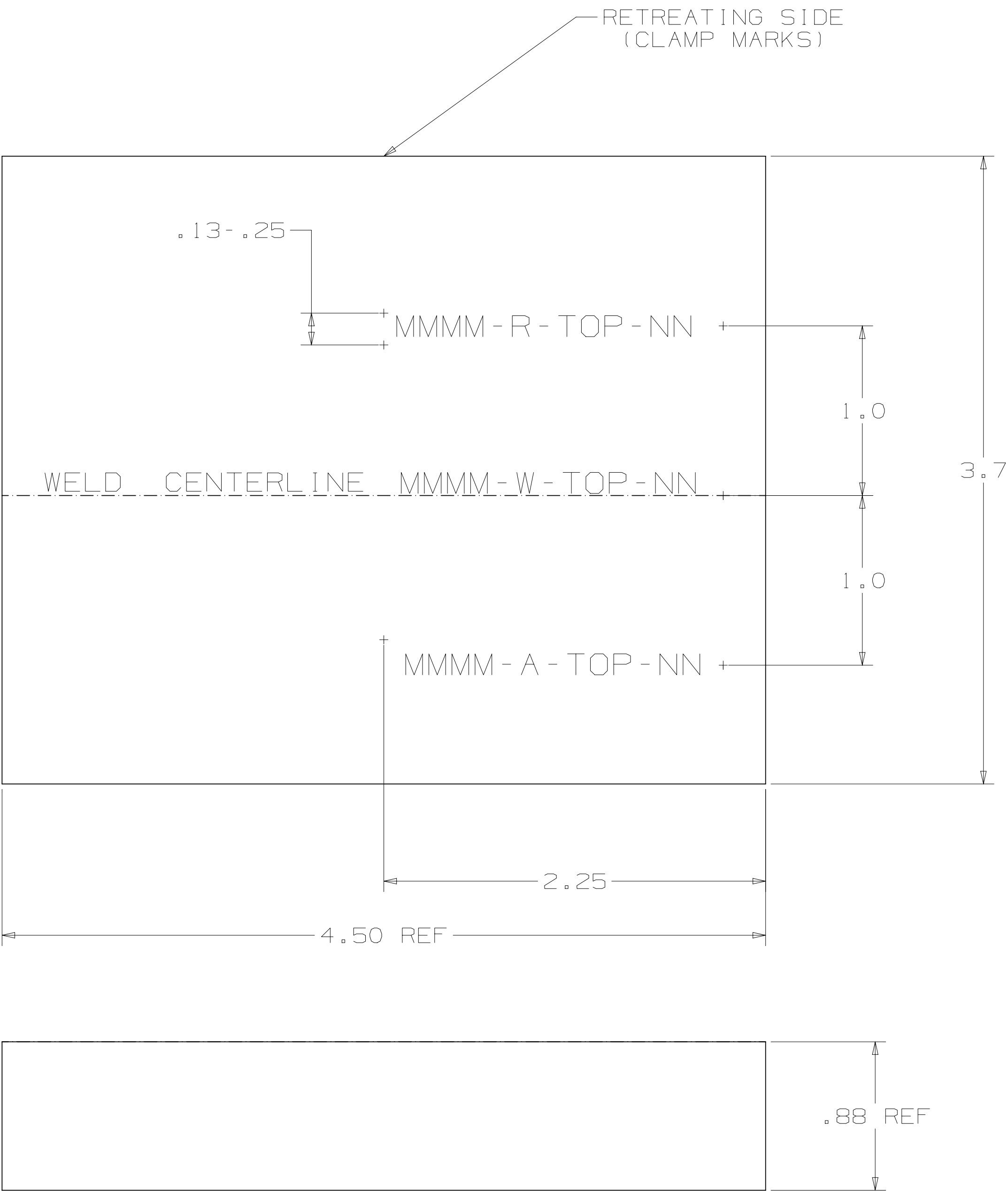
ANGULAR  
±0° 30'

FRACTIONS  
±1/16

1P20  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>					
USAGE: ARMY - FSP				FOCUS CODE MANUFACTURING			
DRAWN BY B.T.		DATE 9/23/11		PART NAME J C TESTING STRIPS			
CHECKED BY R.Z.		DATE 9/23/11		PART NO.			
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



MMMM = 5083

DECIMALS

1 PLACE.....  $\pm .045$   
2 PLACE.....  $\pm .030$   
3 PLACE.....  $\pm .015$   
4 PLACE.....  $\pm .005$

TOLERANCES

ANGULAR  
 $\pm 0^{\circ} 30'$   
FRACTIONS  
 $\pm 1/16$

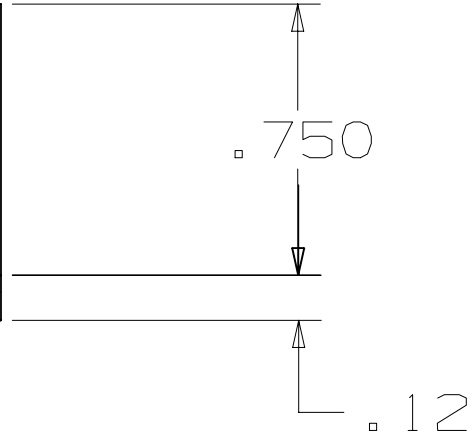
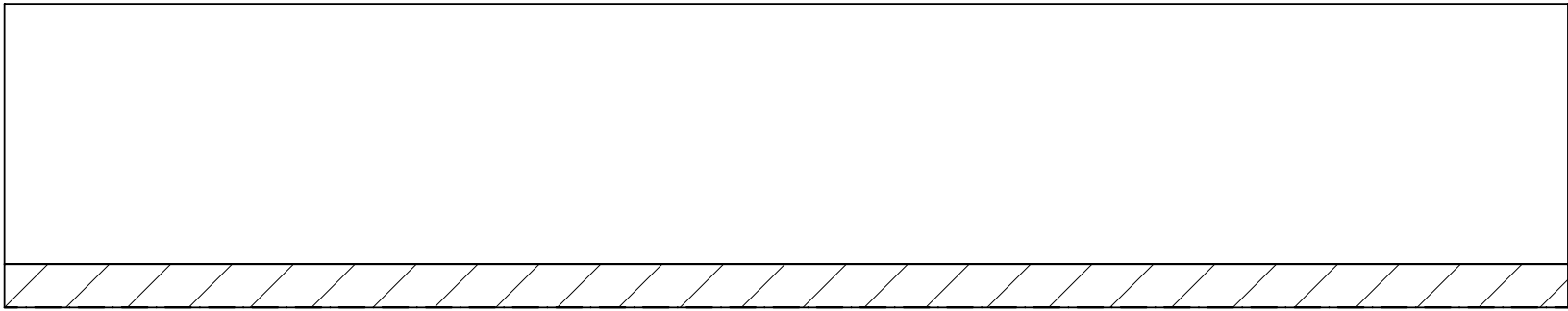
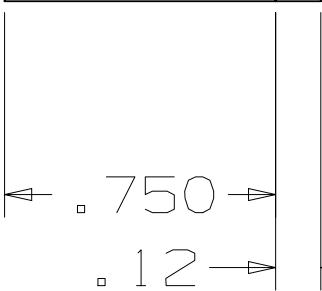
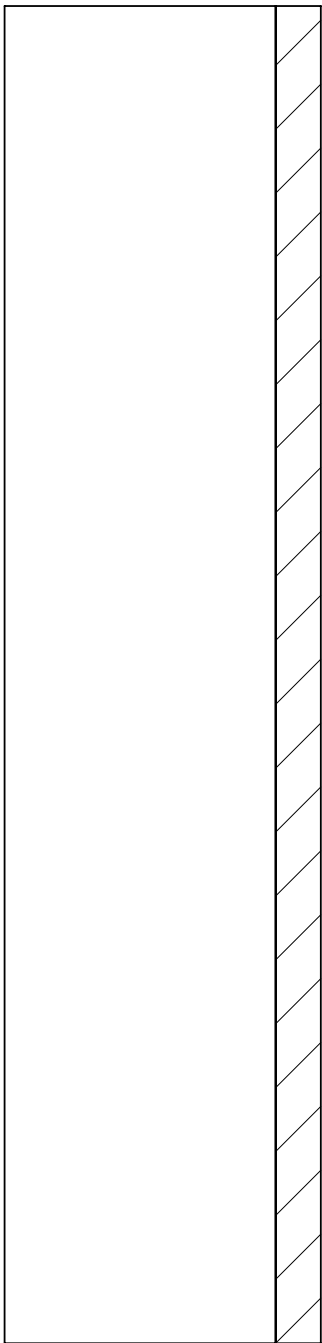
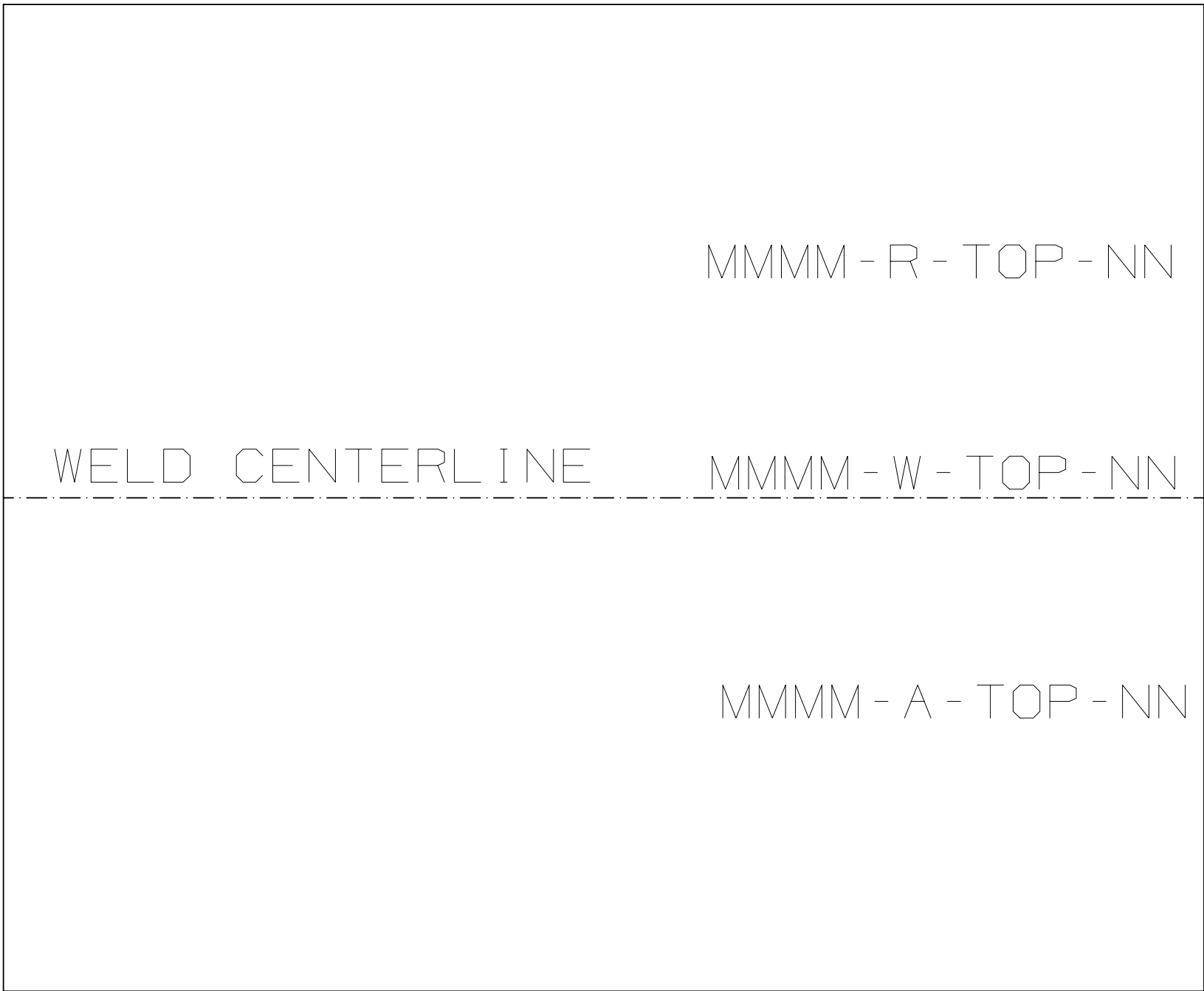
UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL: 5083 ALUMINUM

IP30

DWG

UG CHANGE RESTRICTED				DO NOT SCALE			
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE			
ARMY - FSP				MANUFACTURING			
DRAWN BY B.T.		DATE 9/23/11		PART NAME J C TESTING STRIPS			
CHECKED BY R.Z.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP30_DWG			
RELEASED BY		UNITS INCHES		PART NO.			
		SCALE N/A		SIZE C		DWG LEVEL 100	
				REV		SHEET 1 of 1	

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

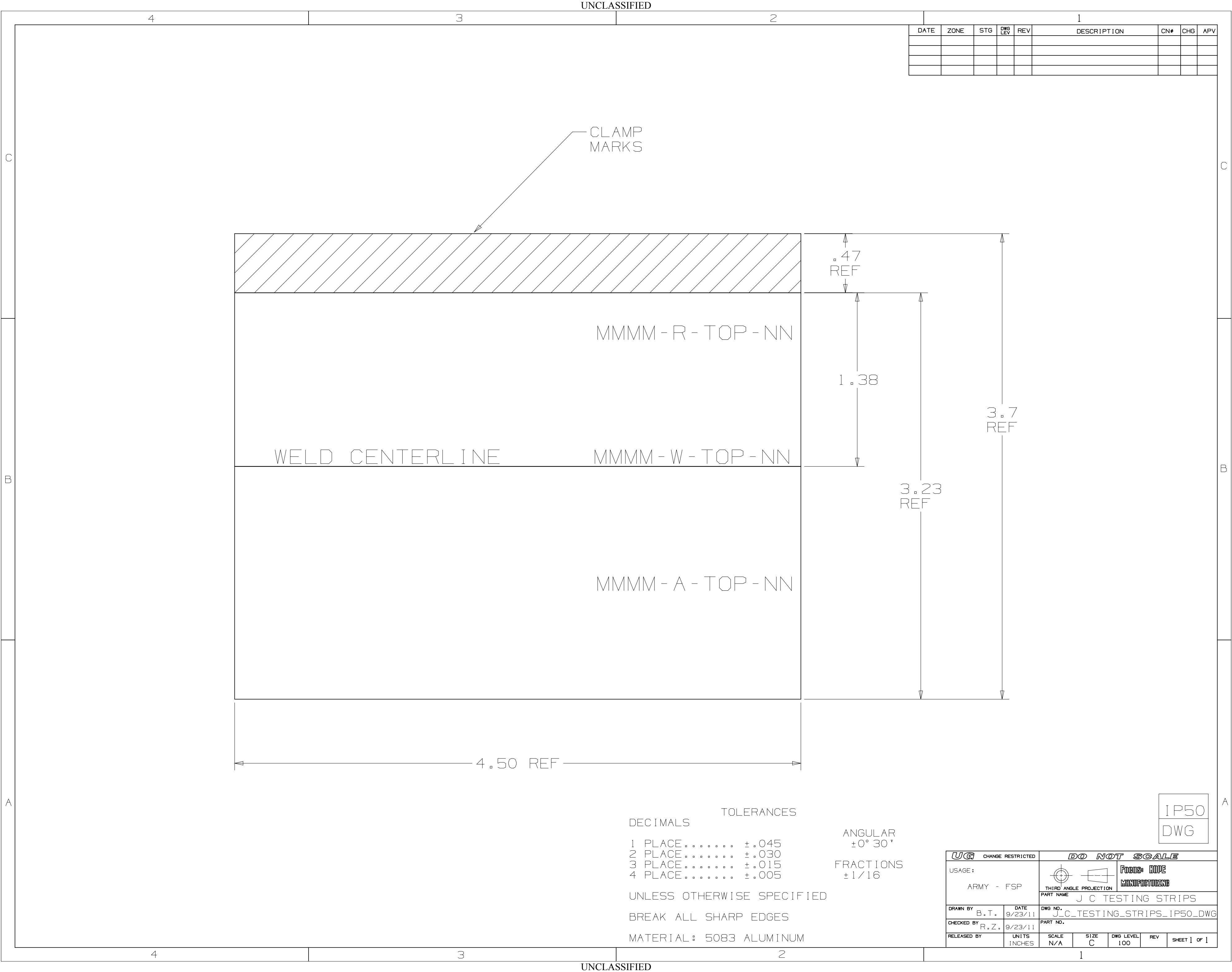


TOLERANCES	
DECIMALS	ANGULAR
1 PLACE..... ±.045	±0° 30'
2 PLACE..... ±.030	
3 PLACE..... ±.015	FRACTIONS
4 PLACE..... ±.005	±1/16

UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL: 5083 ALUMINUM

IP40  
DWG

UG CHANGE RESTRICTED				DO NOT SCALE			
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE			
ARMY - FSP				MANUFACTURING			
DRAWN BY B.T.		DATE 9/23/11		PART NAME J C TESTING STRIPS			
CHECKED BY R.Z.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP40_DWG			
RELEASED BY		UNITS INCHES		PART NO.			
		SCALE N/A		SIZE C		DWG LEVEL 100	
				REV		SHEET 1 OF 1	



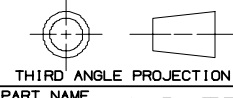
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

DECIMALS	TOLERANCES
1 PLACE.....	±.045
2 PLACE.....	±.030
3 PLACE.....	±.015
4 PLACE.....	±.005

UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL: 5083 ALUMINUM

ANGULAR  
±0° 30'  
FRACTIONS  
±1/16

IP50  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>			
USAGE: ARMY - FSP		 THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP50_DWG	
CHECKED BY R.Z.		DATE 9/23/11		PART NO.	
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
		REV	SHEET 1 of 1		

UNCLASSIFIED

UNCLASSIFIED

4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

RESULT OF CUT OFF

MMMM-R-TOP-NN

.850  $\begin{smallmatrix} +.015 \\ -.000 \end{smallmatrix}$

WELD CENTERLINE

MMMM-W-TOP-NN

.475  $\begin{smallmatrix} +.015 \\ -.000 \end{smallmatrix}$

MMMM-A-TOP-NN

2.48  
REF

4.50 REF

DECIMALS TOLERANCES

1 PLACE.....  $\pm .045$   
2 PLACE.....  $\pm .030$   
3 PLACE.....  $\pm .015$   
4 PLACE.....  $\pm .005$

UNLESS OTHERWISE SPECIFIED

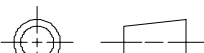
BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

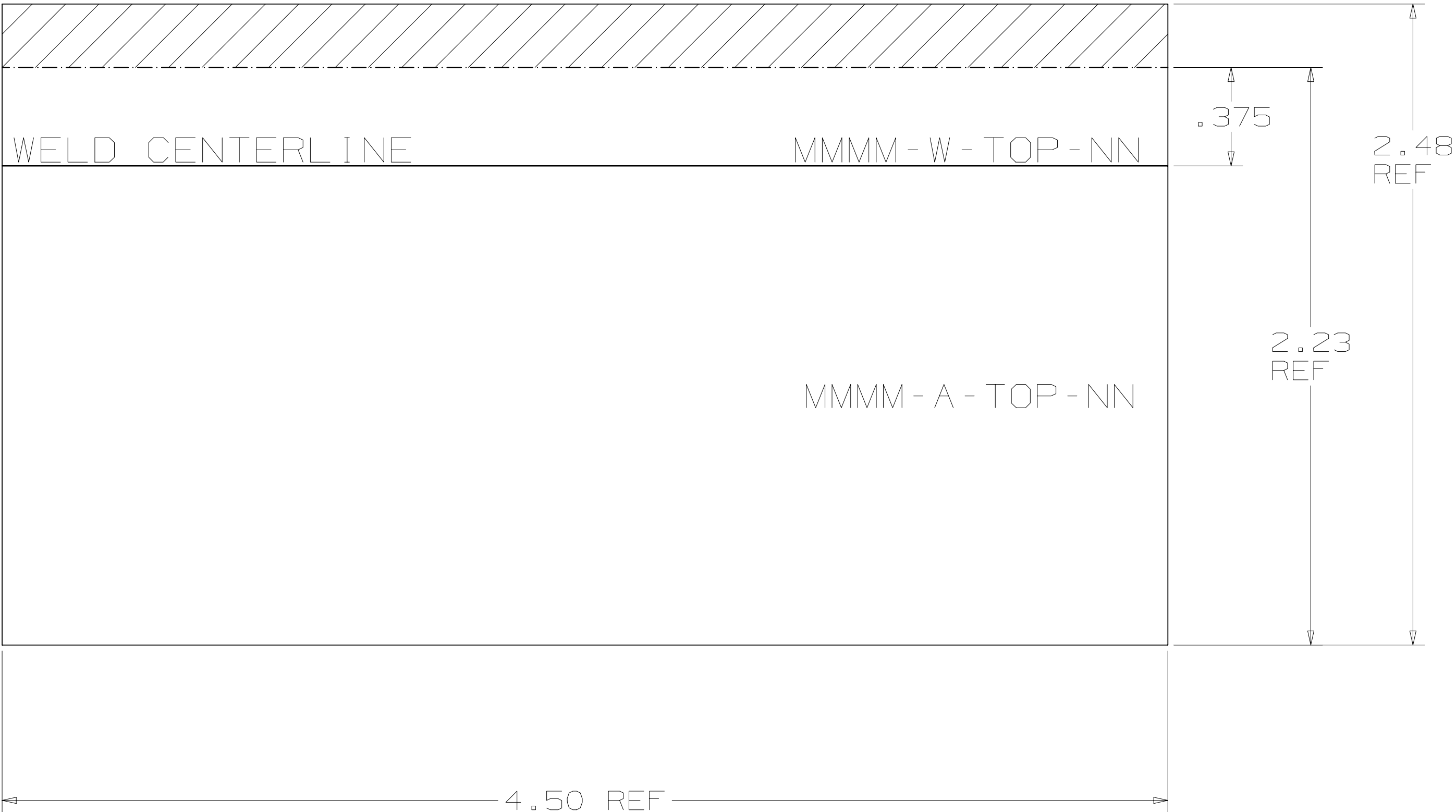
ANGULAR  
 $\pm 0^{\circ} 30'$

FRACTIONS  
 $\pm 1/16$

IP60  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE											
USAGE:  ARMY - FSP				FOCUS: HOPE MANUFACTURED									
		THIRD ANGLE PROJECTION											
		PART NAME		J C TESTING STRIPS									
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP60_DWG									
CHECKED BY R.Z.		9/23/11		PART NO.									
RELEASED BY		UNITS INCHES		SCALE N/A		SIZE C		DWG LEVEL 100		REV		SHEET 1 of 1	

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES

1 PLACE..... ±.045 ANGULAR ±0° 30'

2 PLACE..... ±.030

3 PLACE..... ±.015 FRACTIONS ±1/16

4 PLACE..... ±.005

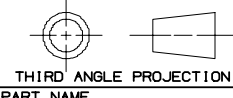
UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

IP70

DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>						
USAGE:				FOCUS CODE				
ARMY - FSP				MANUFACTURING				
PART NAME		J C TESTING STRIPS						
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP70_DWG				
CHECKED BY R.Z.		9/23/11		PART NO.				
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1

4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

C

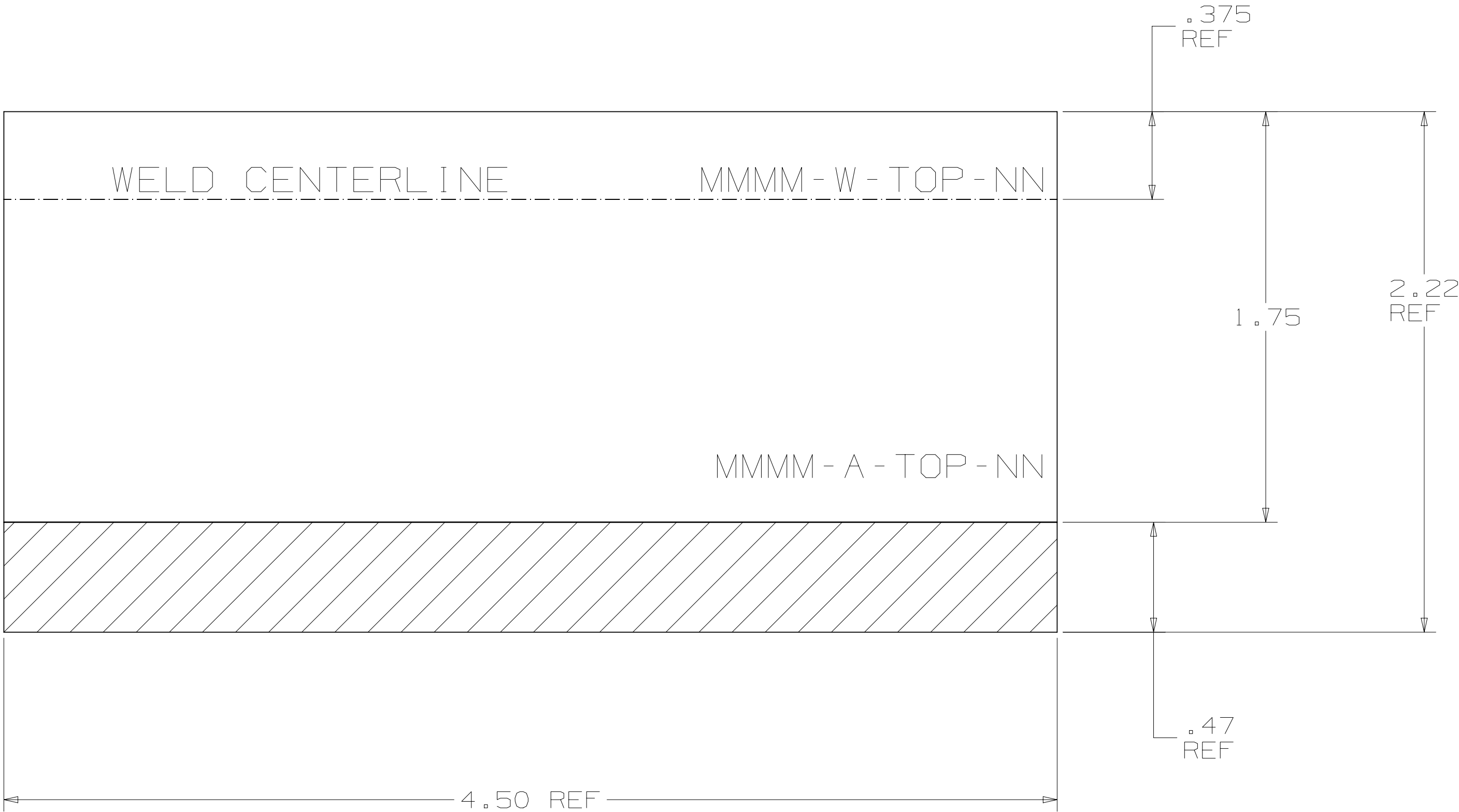
C

B

B

A

A



DECIMALS                      TOLERANCES

1 PLACE..... ±.045                      ANGULAR  
2 PLACE..... ±.030                      ±0° 30'

3 PLACE..... ±.015                      FRACTIONS  
4 PLACE..... ±.005                      ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

IP80  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE				
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE		
ARMY - FSP		PART NAME		J C TESTING STRIPS		
DRAWN BY	DATE	DWG NO.		J_C_TESTING_STRIP_IP80_DWG		
B.T.	9/23/11	PART NO.				
CHECKED BY	9/23/11	SCALE		SIZE	DWG LEVEL	REV
R.Z.		N/A		C	100	
RELEASED BY	UNITS	SHEET 1 of 1				
	INCHES					

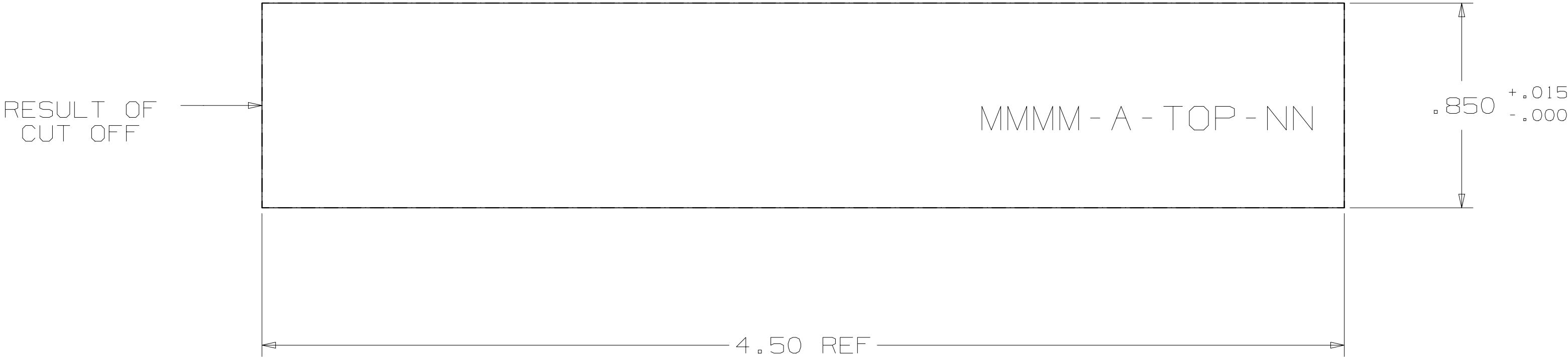
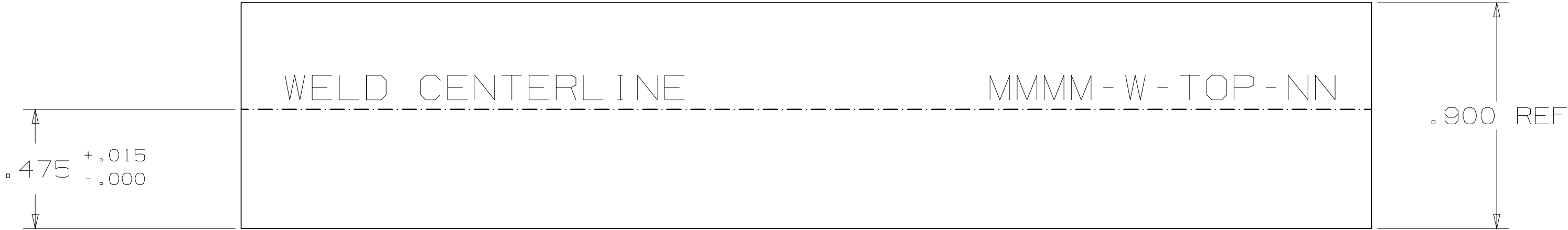
4

3

2

1

1							
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION		CN#
							CHG
							APV



DECIMALS TOLERANCES

- 1 PLACE.....  $\pm .045$
- 2 PLACE.....  $\pm .030$
- 3 PLACE.....  $\pm .015$
- 4 PLACE.....  $\pm .005$

ANGULAR  
 $\pm 0^{\circ} 30'$

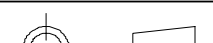
FRACTIONS  
 $\pm 1/16$

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

IP90  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE						
USAGE:				FOCUS: ROPE MANUFACTURING				
ARMY - FSP		THIRD ANGLE PROJECTION						
		PART NAME		J C TESTING STRIPS				
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP90_DWG				
CHECKED BY R.Z.		9/23/11		PART NO.				
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1



4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

C

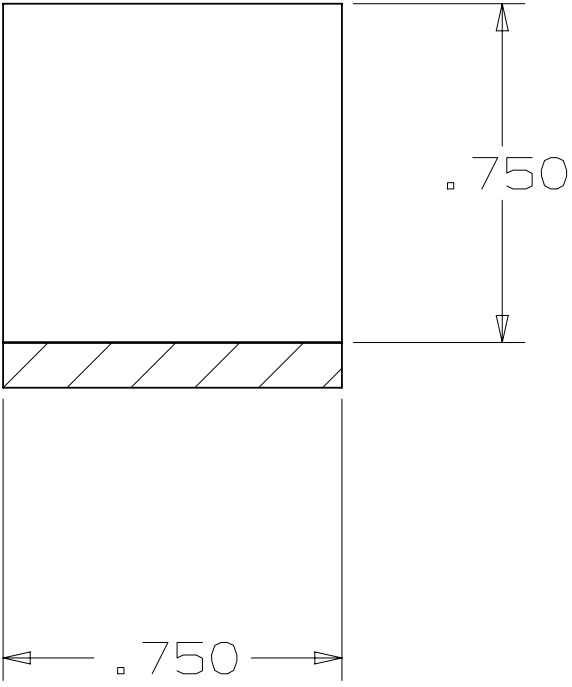
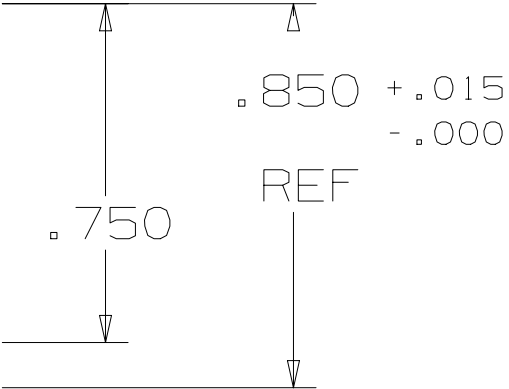
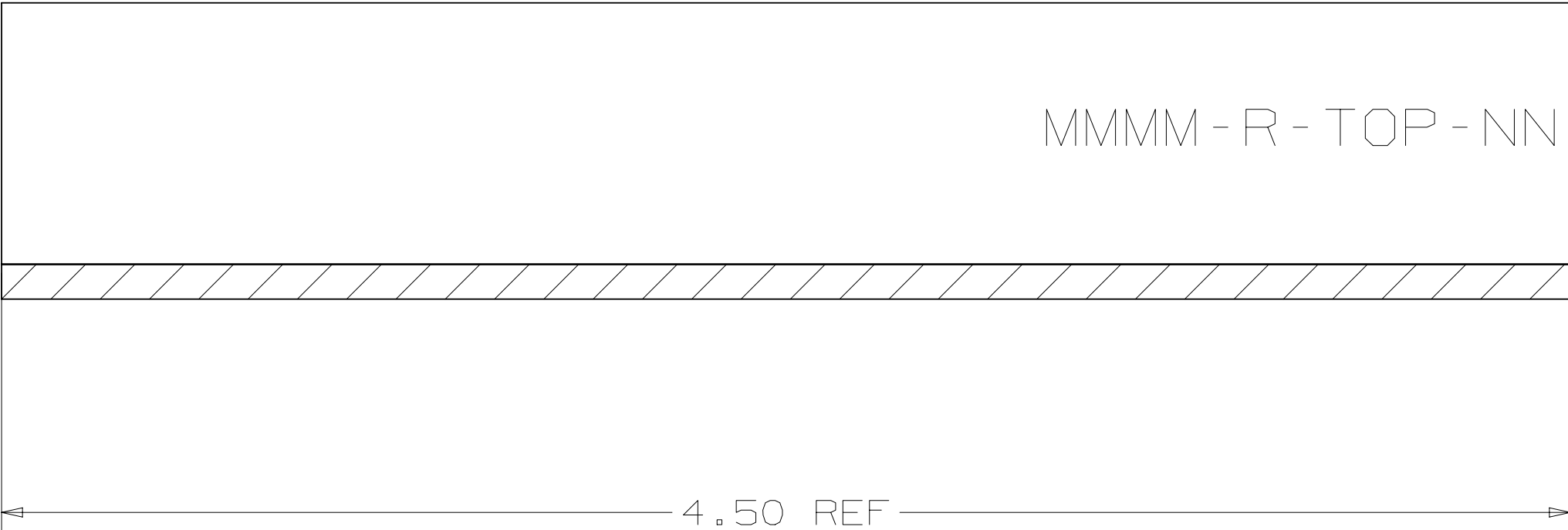
C

B

B

A

A



DECIMALS                      TOLERANCES

1 PLACE..... ±.045                      ANGULAR  
2 PLACE..... ±.030                      ±0° 30'

3 PLACE..... ±.015                      FRACTIONS  
4 PLACE..... ±.005                      ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

IP110  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE					
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE			
ARMY - FSP		PART NAME		J C TESTING STRIPS			
DRAWN BY	B.T.	DATE	9/23/11	DWG NO.	J C TESTING STRIPS_IP110_DWG		
CHECKED BY	R.Z.	DATE	9/23/11	PART NO.			
RELEASED BY		UNITS	INCHES	SCALE	N/A	SIZE	C
				DWG LEVEL	100	REV	
						SHEET	1 of 1

4

3

2

1

4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

C

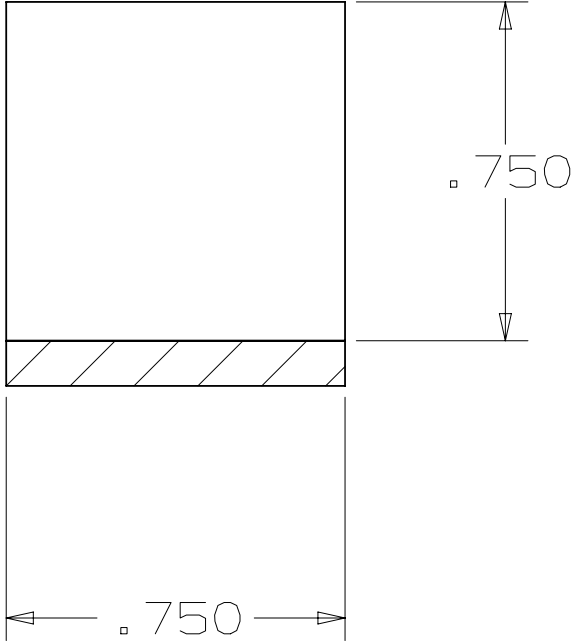
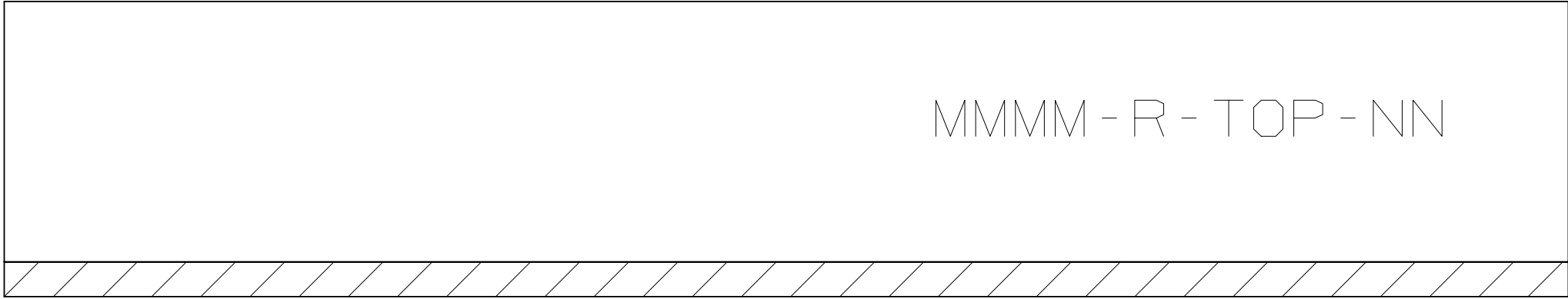
C

B

B

A

A



DECIMALS                      TOLERANCES

1 PLACE..... ±.045                      ANGULAR  
2 PLACE..... ±.030                      ±0° 30'

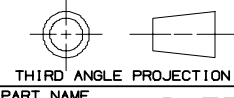
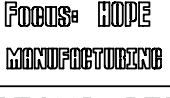
3 PLACE..... ±.015                      FRACTIONS  
4 PLACE..... ±.005                      ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

IP120  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>						
USAGE: ARMY - FSP		 THIRD ANGLE PROJECTION		 FOCUS CODE MANUFACTURING				
DRAWN BY B.T.		DATE 9/23/11		PART NAME J C TESTING STRIPS				
CHECKED BY R.Z.		DATE 9/23/11		PART NO. JLC_TESTING_STRIPS_IP120_DWG				
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1

4

3

2

1

4

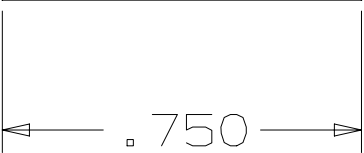
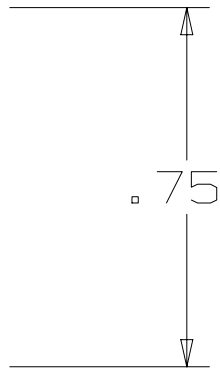
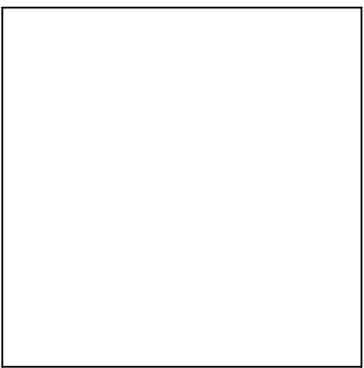
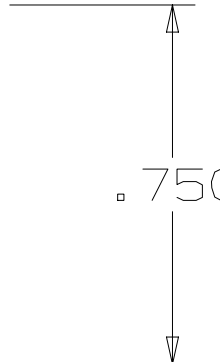
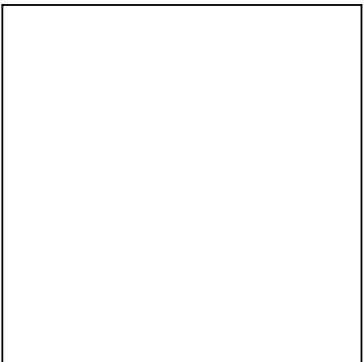
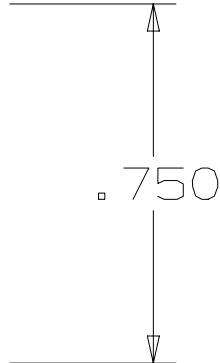
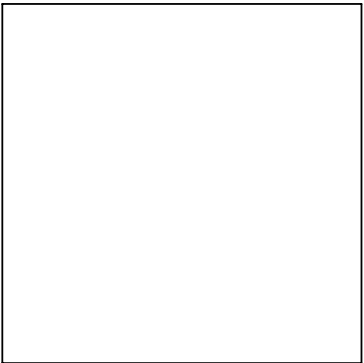
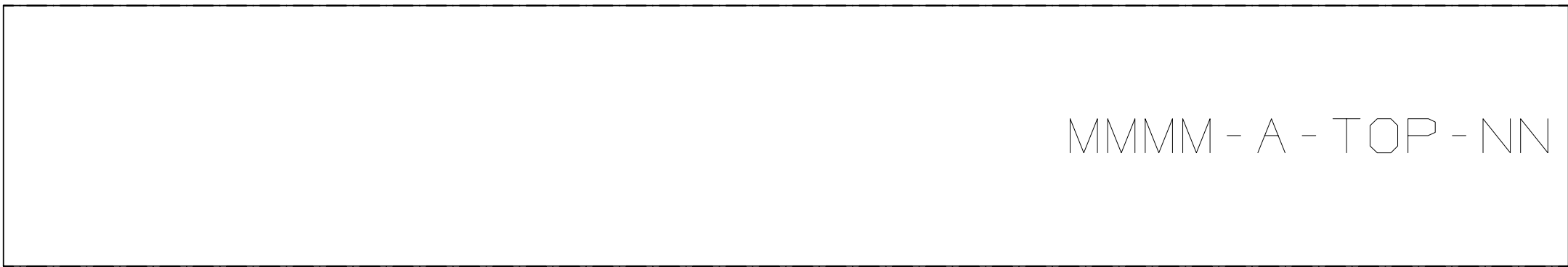
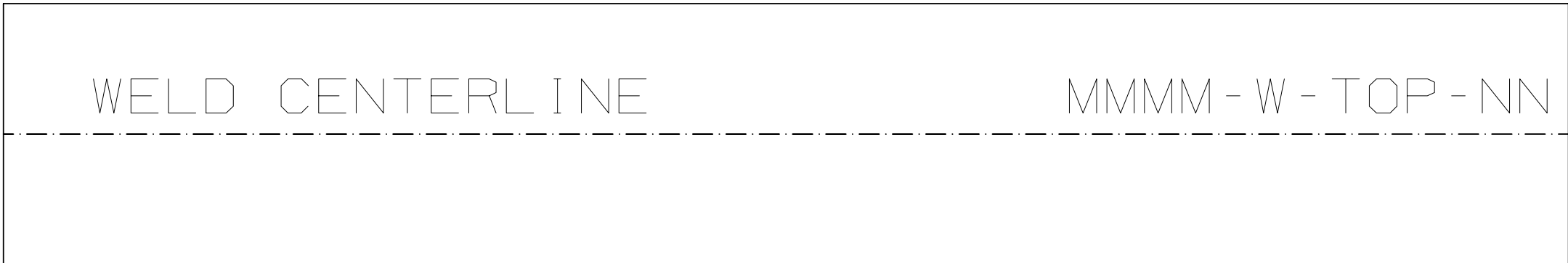
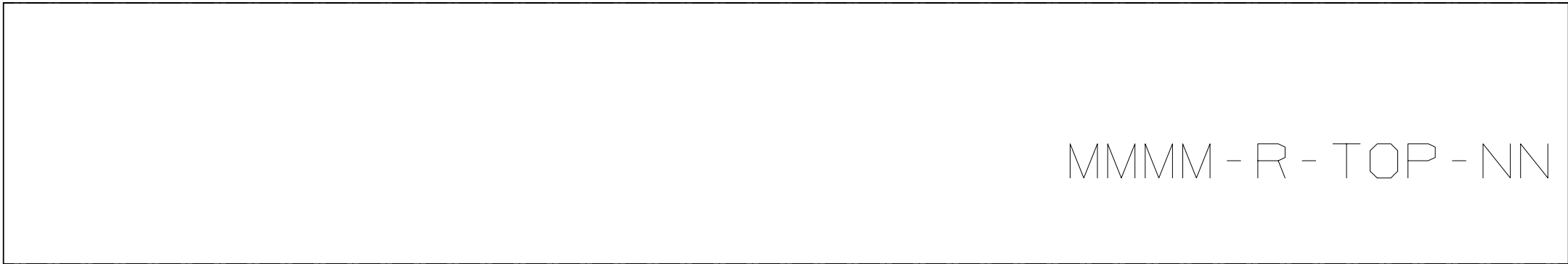
3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

TOP VIEW OF 3 FINISHED BLOCKS



DECIMALS TOLERANCES

1 PLACE..... ±.045

2 PLACE..... ±.030

3 PLACE..... ±.015

4 PLACE..... ±.005

ANGULAR  
±0° 30'


FRACTIONS  
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

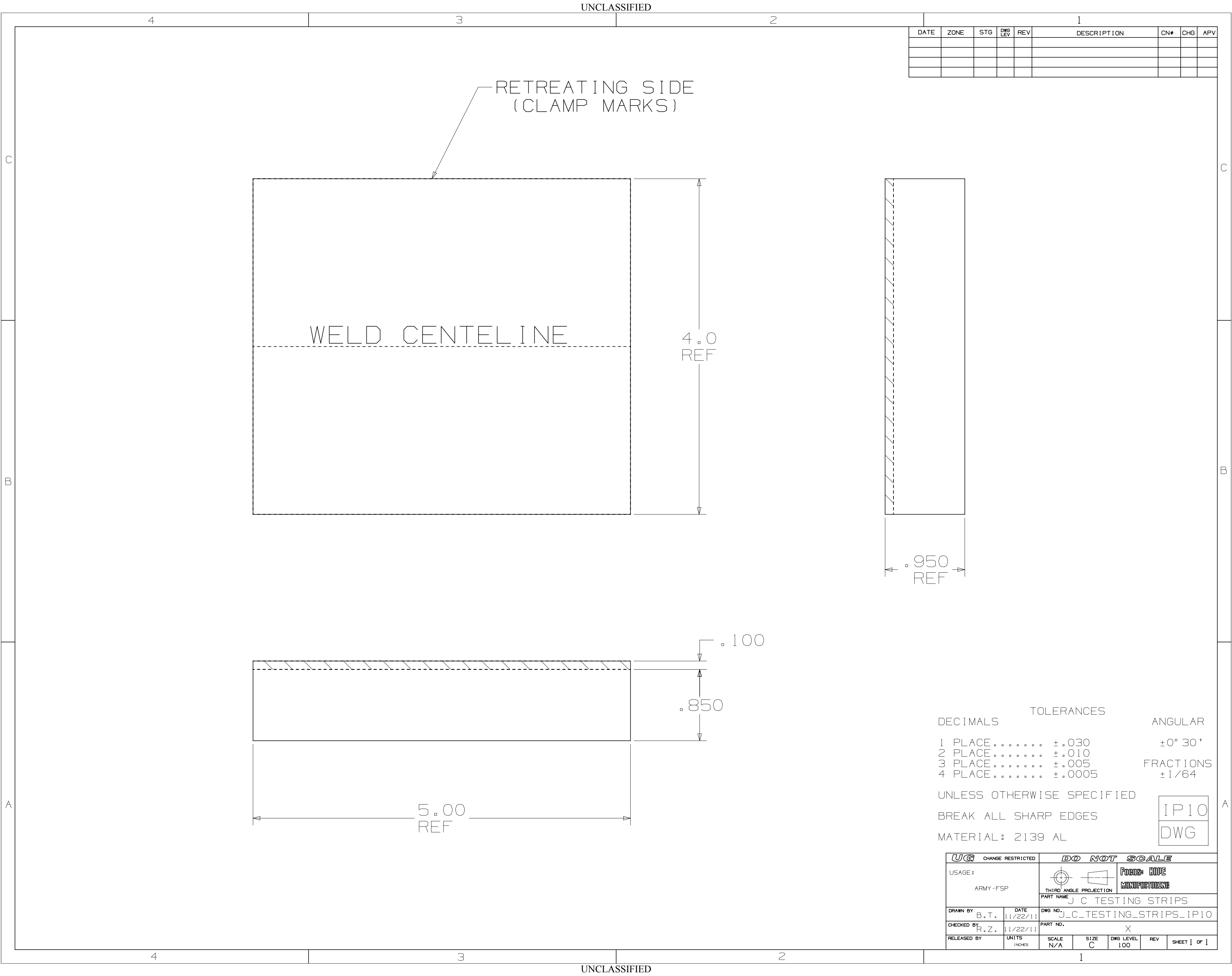
MATERIAL: 5083 ALUMINUM

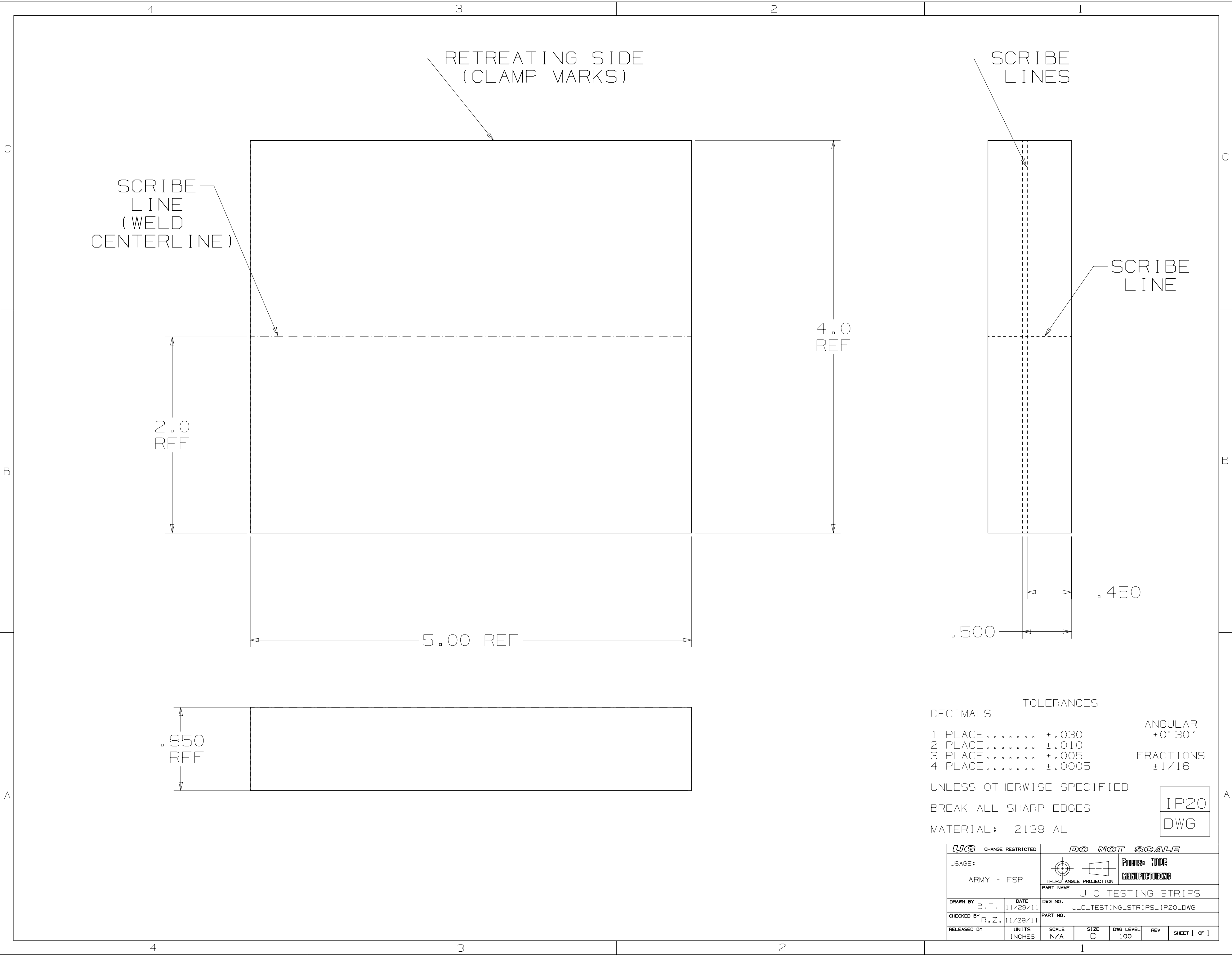
IP130  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE											
USAGE:				FOCUS: ROPE MANUFACTURING									
ARMY - FSP		THIRD ANGLE PROJECTION		PART NAME J C TESTING STRIPS									
DRAWN BY B.T.		DATE 9/23/11											
CHECKED BY R.Z.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP130-DWG									
RELEASED BY		UNITS INCHES		SCALE N/A		SIZE C		DWG LEVEL 100		REV		SHEET 1 of 1	

**Focus: HOPE Process routing/Shop traveler**

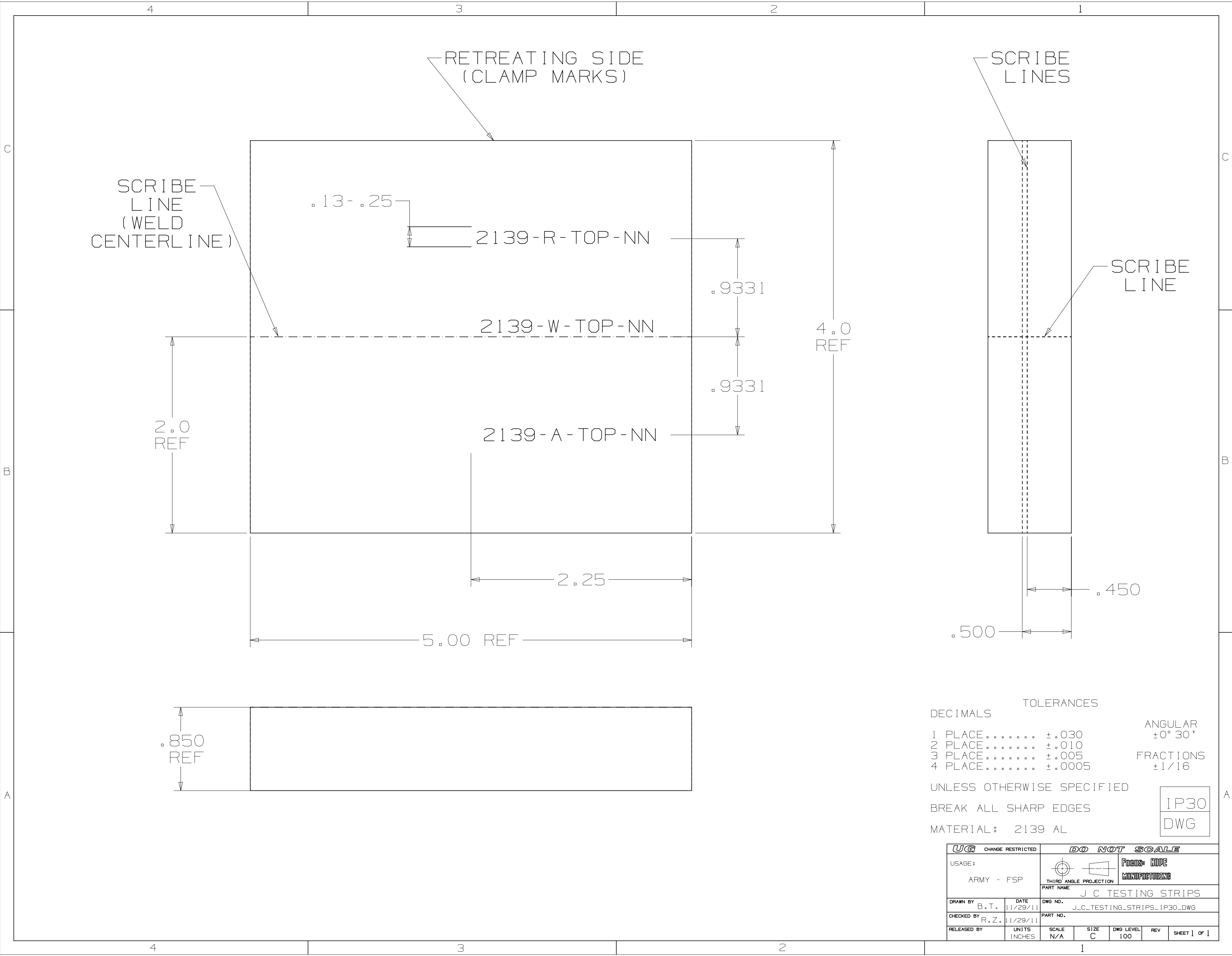
Customer: <b>Southwest Research Institute</b>		
Street Address:		
City State Zip:		
Stock: <b>4 x 4.850 x .950 coupon (54)</b>		
Part Number: <b>Strips</b>		
Description: <b>Johnson-Cook test specimen blocks (2139)</b>		
Revision:		
Op No	Labor Code	Operation Description
10	Mill	Mill TOP to 0.850
20	Height Gage & Scribe	Find, and scribe weld centerlines on Top and Ends of block.
30	Laser Marker	Mark TOP face of coupon per print (MMMM-X-TOP-NN, Where X=A,W, or R)
40	Mill	Mill BOTTOM to 0.800 thick
50	Mill	Mill coupon to 1.2456 from weld centerline (retreating side)
60	Band Saw	Saw Block R(retreating side) to .675 SET ASIDE
70	Mill	Mill coupon to .400 from weld centerline (retreating side)
80	Mill	Flip around (TOP still facing up) and mill coupon to 1.6456
90	Band Saw	Saw block at 'A' to .675 and remaining strip 'W' at .9706 ref
100	Mill	Mill 'W' to .800 (from saw cut side)
110	Mill	Mill R to .625 (From saw cut side)
120	Mill	Mill A to .625 (from saw cut side)
130	Mill	Mill block 'R' BOTTOM .1375 REF to 0.6535
140	Mill	Mill block 'R' TOP .0285 REF to 0.625
150	Mill	Mill block 'A' BOTTOM .1375 REF to 0.6535
160	Mill	Mill block 'A' TOP .0285 REF to 0.625
170		Measurement of finished blocks, per inspection check sheet

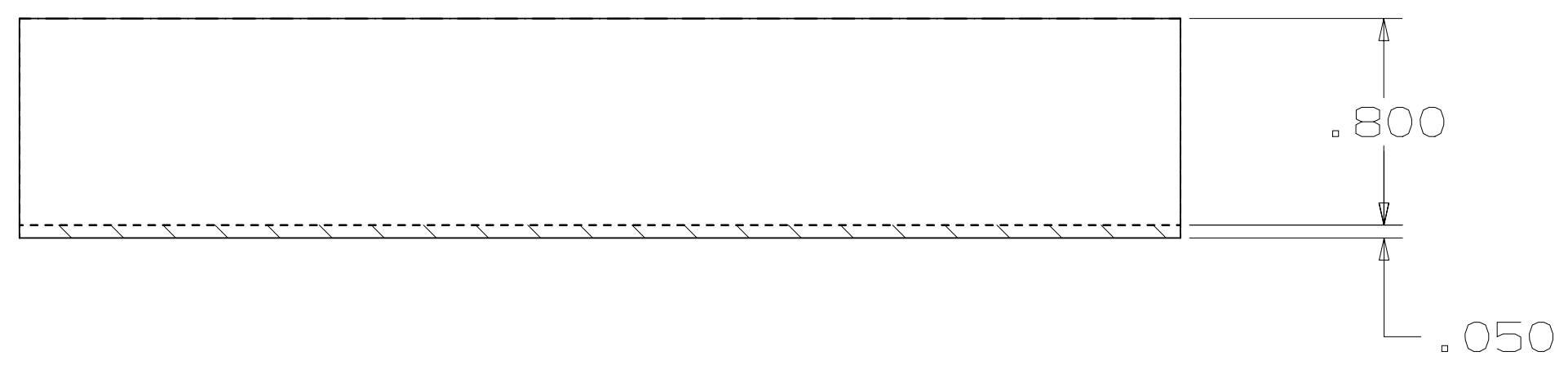
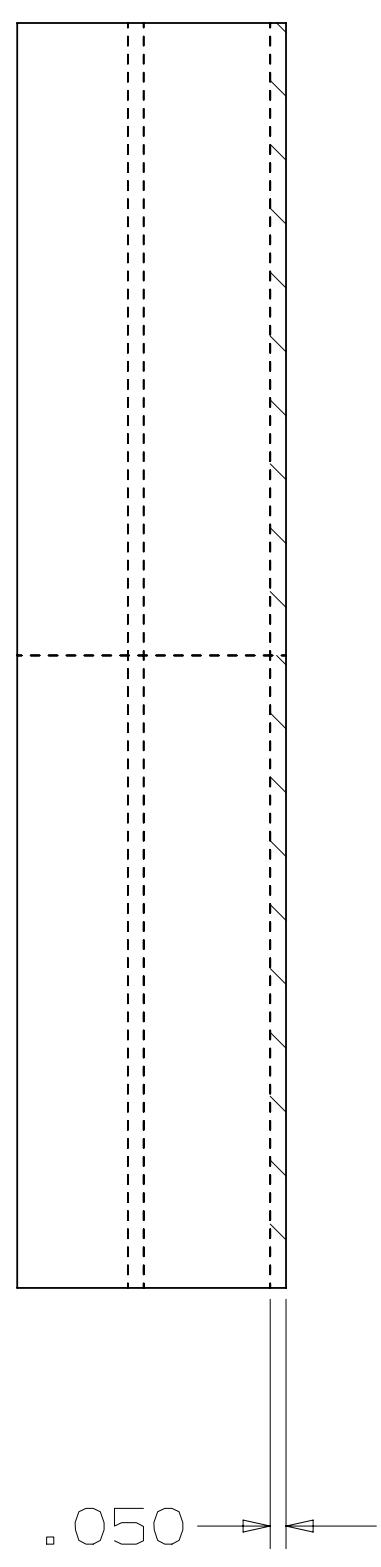
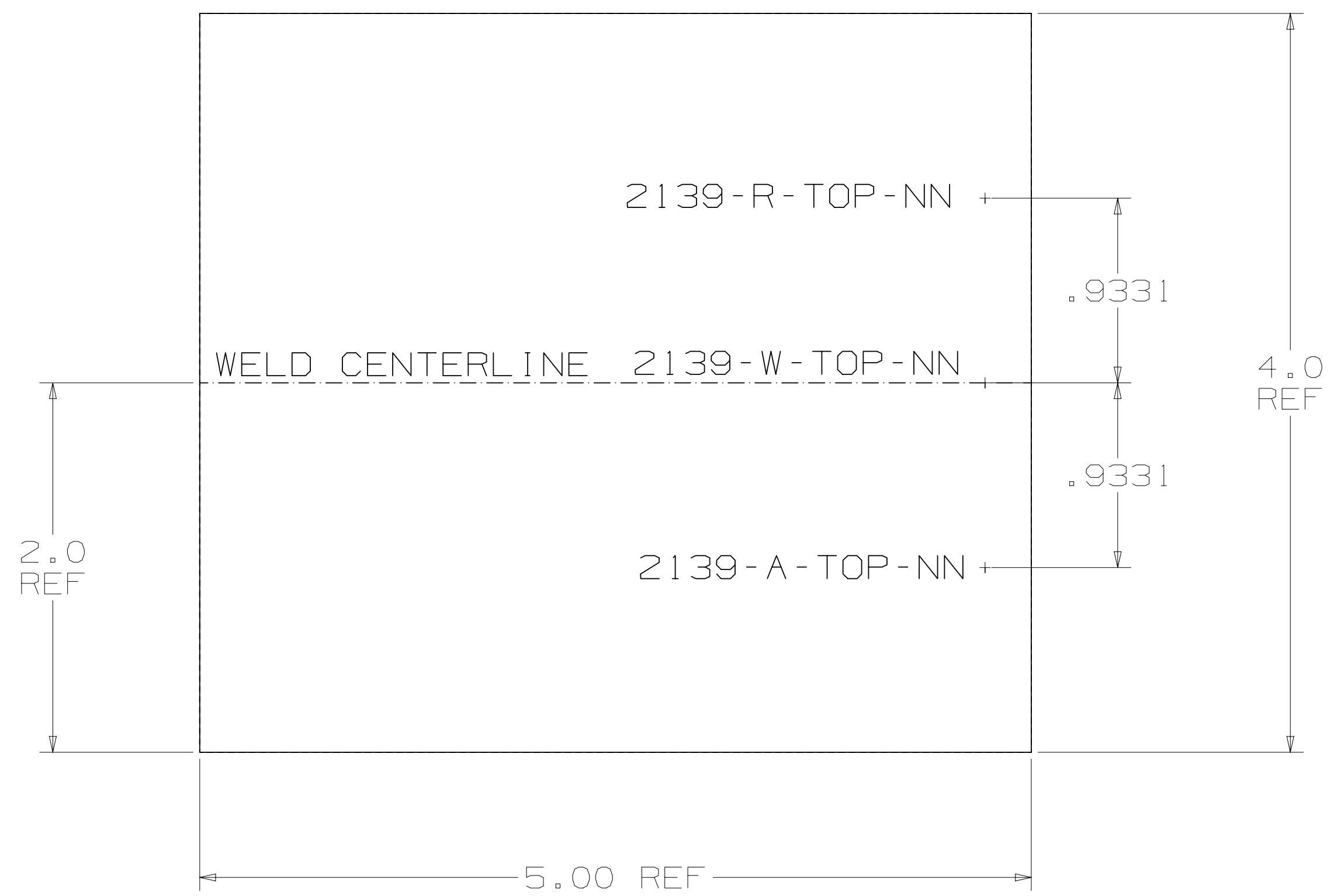




DECIMALS		TOLERANCES	
1	PLACE.....	±.030	ANGULAR ±0° 30'
2	PLACE.....	±.010	
3	PLACE.....	±.005	FRACTIONS ±1/16
4	PLACE.....	±.0005	
UNLESS OTHERWISE SPECIFIED			
BREAK ALL SHARP EDGES			
MATERIAL: 2139 AL			
1P20		DWG	

UG CHANGE RESTRICTED		DO NOT SCALE	
USAGE:		THIRD ANGLE PROJECTION	
ARMY - FSP		PART NAME	
DATE		J.C. TESTING STRIPS	
B.T. 11/29/11		J.C. TESTING STRIPS_1P20_DWG	
CHECKED BY		PART NO.	
R.Z. 11/29/11			
RELEASED BY		SCALE	SIZE
		N/A	C
UNITS		DWG LEVEL	REV
INCHES		100	
		SHEET 1 OF 1	





DECIMALS TOLERANCES

1 PLACE.....	±.030	ANGULAR	±0° 30'
2 PLACE.....	±.010	FRACTIONS	±1/16
3 PLACE.....	±.005		
4 PLACE.....	±.0005		

UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL: 2139 AL

IP40

DWG

UG CHANGE RESTRICTED		DO NOT SCALE					
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE			
ARMY - FSP		PART NAME		MANUFACTURING			
DRAWN BY B.T.		DATE 11/29/11		J C TESTING STRIPS			
CHECKED BY R.Z.		DATE 11/29/11		J.C.TESTING_STRIPS_IP40_DWG			
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100	REV
							SHEET 1 of 1



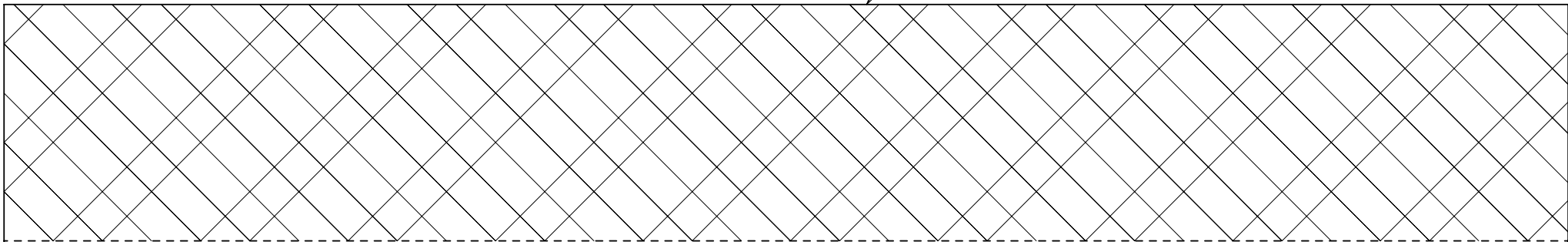
4

3

2

1

CLAMP MARKS



2139-R-TOP-NN

WELD CENTERLINE

2139-W-TOP-NN

2139-A-TOP-NN

.7544  
REF

1.2456

3.2456  
REF

4.0  
REF

5.00 REF

DECIMALS

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES


MATERIAL: 2139 AL

TOLERANCES

ANGULAR  
±0° 30'

FRACTIONS  
±1/16

IP50  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE					
USAGE:				FOCUS CODE			
ARMY - FSP				MANUFACTURING			
		THIRD ANGLE PROJECTION					
		PART NAME		J C TESTING STRIPS			
DRAWN BY B.T.		DATE 11/29/11		DWG NO.		J_C_TESTING_STRIPS_IP50_DWG	
CHECKED BY R.Z.		UNITS 11/29/11		PART NO.			
RELEASED BY		UNITS INCHES		SCALE N/A		SIZE C	
				DWG LEVEL 100		REV	
						SHEET 1 OF 1	

RESULT OF CUTOFF

2139-R-TOP-NN

.675 ±.015

WELD CENTERLINE

2139-W-TOP-NN

.4456 ±.015

2139-A-TOP-NN

2.4456

5.00 REF

DECIMALS TOLERANCES

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED


BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

ANGULAR  
±0° 30'

FRACTIONS  
±1/16

IP60  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE					
USAGE:				FOCUS CODE MANUFACTURING			
ARMY - FSP							
		PART NAME					
		J C TESTING STRIPS					
DRAWN BY	B.T.	DATE	DWG NO.				
		11/29/11	J_C_TESTING_STRIPS_IP60_DWG				
CHECKED BY	R.Z.	11/29/11	PART NO.				
RELEASED BY	UNITS	SCALE	SIZE	DWG LEVEL	REV	SHEET 1 OF 1	
	INCHES	N/A	C	100			

4

3

2

1

C

C

B

B

A

A



DECIMALS TOLERANCES

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

ANGULAR  
±0° 30'

FRACTIONS  
±1/16

IP70  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE				
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE		
ARMY - FSP		PART NAME		MANUFACTURING		
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C.TESTING_STRIPS_IP70_DWG		
CHECKED BY R.Z.		DATE 11/29/11		PART NO.		
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100
				REV	SHEET 1 of 1	

4

3

2

1

C

C

B

B

A

A



DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR ±0° 30'

FRACTIONS ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE	
ARMY - FSP				MANUFACTURING	
PART NAME		J C TESTING STRIPS			
DRAWN BY	DATE	DWG NO.			
B.T.	11/29/11	J.C._TESTING_STRIPS_IP80_DWG			
CHECKED BY	DATE	PART NO.			
R.Z.	11/29/11				
RELEASED BY	UNITS	SCALE	SIZE	DWG LEVEL	REV
	INCHES	N/A	C	100	
SHEET 1 of 1					

4

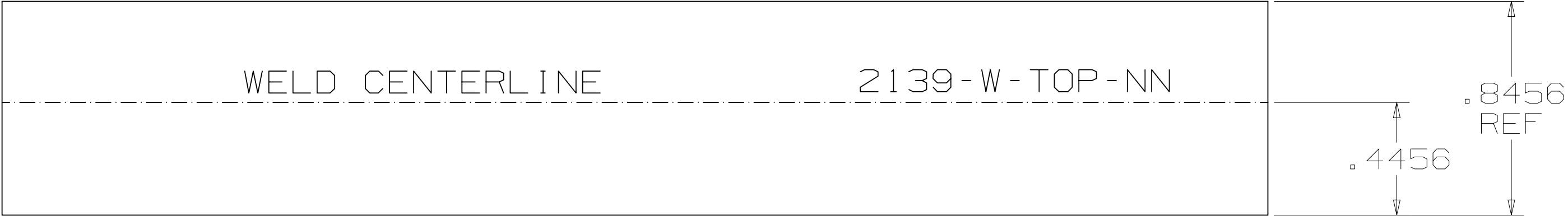
3

2

1

C

C



RESULT OF CUTOFF



B

B

A

A

DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR ±0° 30'

FRACTIONS ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP90  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE					
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE			
ARMY - FSP		PART NAME		MANUFACTURING			
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C.TESTING_STRIPS_IP90_DWG			
CHECKED BY R.Z.		DATE 11/29/11		PART NO.			
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1



DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR ±0° 30'

FRACTIONS ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE:		THIRD ANGLE PROJECTION		FOCUS: CODE	
ARMY - FSP		PART NAME		MANUFACTURING	
J C TESTING STRIPS					
DRAWN BY	B.T.	DATE	11/29/11	DWG NO.	J.C_TESTING_STRIPS_IP100_DWG
CHECKED BY	R.Z.	DATE	11/29/11	PART NO.	
RELEASED BY		UNITS	INCHES	SCALE	N/A
		SIZE	C	DWG LEVEL	100
		REV		SHEET	1 of 1

4

3

2

1

C

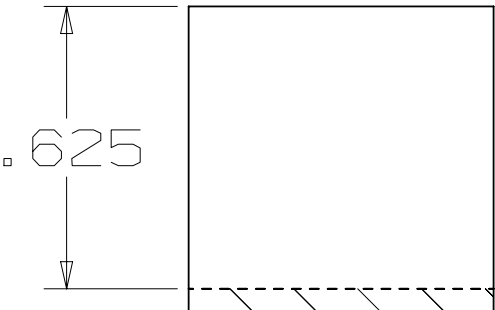
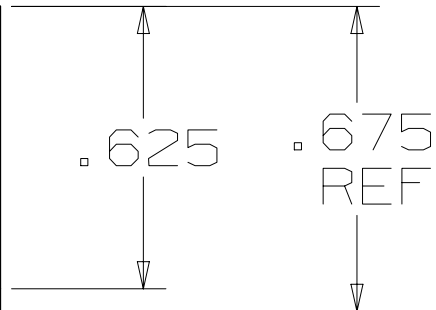
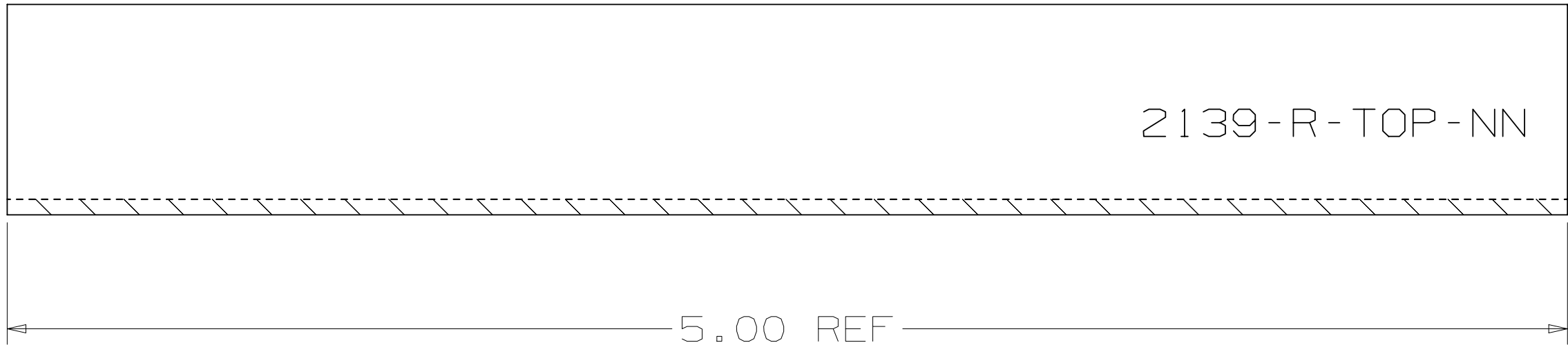
C

B

B

A

A



DECIMALS                      TOLERANCES

1 PLACE..... ±.030                      ANGULAR  
2 PLACE..... ±.010                      ±0° 30'

3 PLACE..... ±.005                      FRACTIONS  
4 PLACE..... ±.0005                      ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>				
USAGE: ARMY - FSP		 THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING		
PART NAME		J C TESTING STRIPS				
DRAWN BY B.T.	DATE 11/29/11	DWG NO. J.C_TESTING_STRIPS_IP110_DWG				
CHECKED BY R.Z.	11/29/11	PART NO.				
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1

IP110  
DWG

4

3

2

1



4

3

2

1

C

C

B

B

A

A

SAW CUT

2139-A-TOP-NN

.625

.675  
REF

.625

.850

5.00 REF

DECIMALS

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

TOLERANCES

ANGULAR  
±0° 30'


FRACTIONS  
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP120  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE				
USAGE:				FOCUS CODE MANUFACTURING		
ARMY - FSP						
		PART NAME				
		J C TESTING STRIPS				
DRAWN BY B. T.		DATE 11/29/11		DWG NO. J_C_TESTING_STRIPS_IP120_DWG		
CHECKED BY R. Z.		DATE 11/29/11		PART NO.		
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV
						SHEET 1 of 1

4

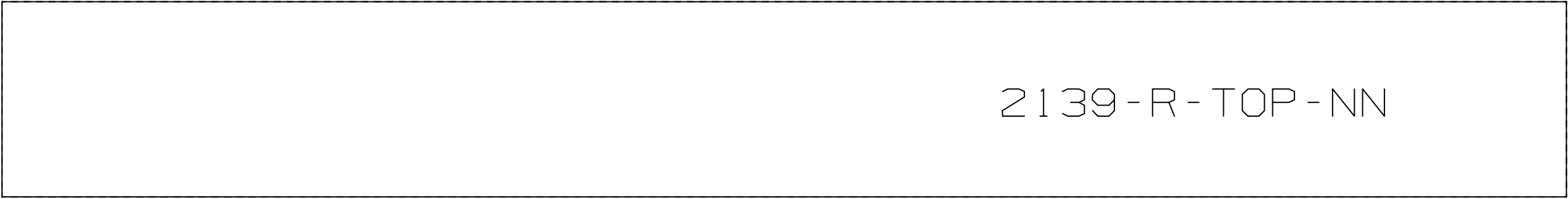
3

2

1

C

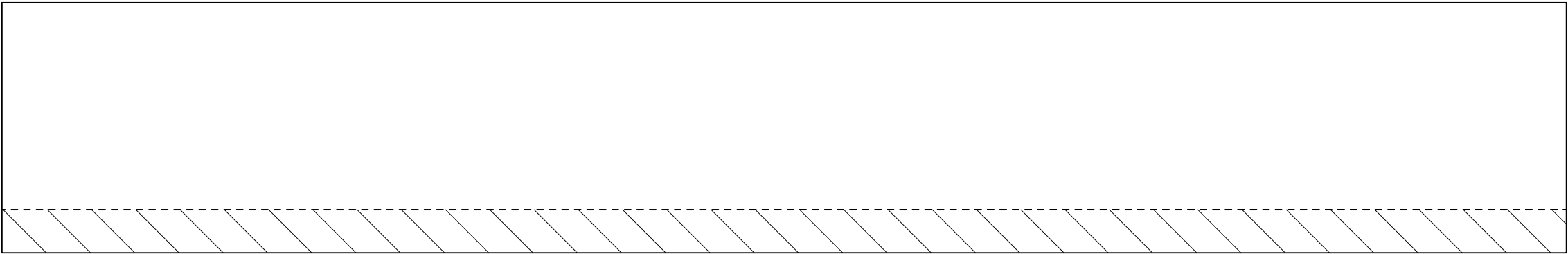
C



2139-R-TOP-NN

B

B



.6625

.1375

.800

.625

A

A

DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR ±0° 30'

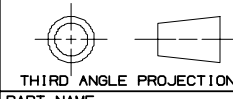
FRACTIONS ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP130  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE						
USAGE:				FOCUS CODE MANUFACTURING				
ARMY - FSP								
		THIRD ANGLE PROJECTION						
		PART NAME						
		J C TESTING STRIPS						
DRAWN BY B.T.		DATE 11/29/11		DWG NO.			J_C_TESTING_STRIPS_IP130_DWG	
CHECKED BY R.Z.		DATE 11/29/11		PART NO.				
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 OF 1

4

3

2

1

C

C

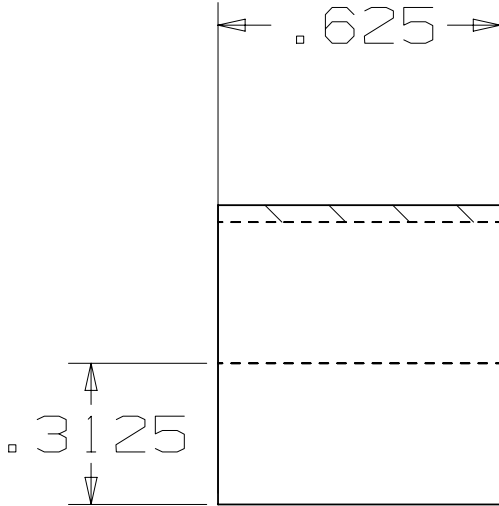
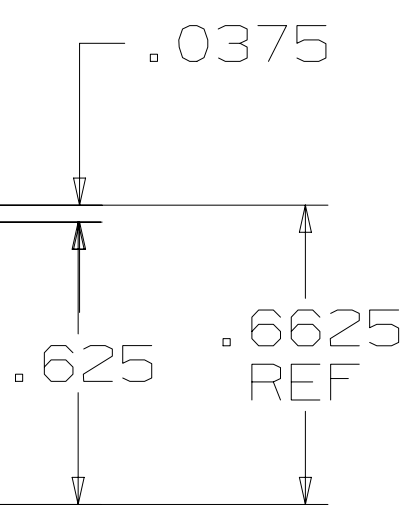
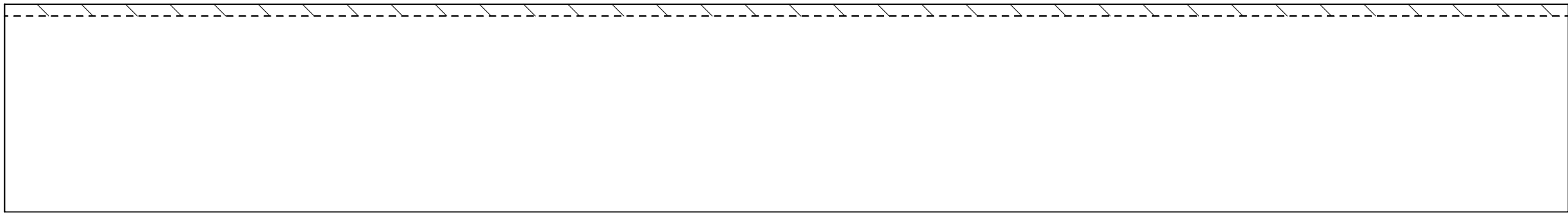
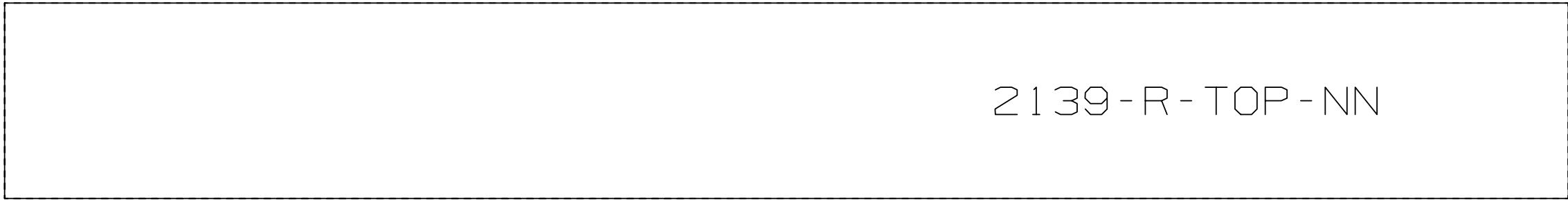
B

B

A

A

2139-R-TOP-NN



DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR ±0° 30'

FRACTIONS ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP140  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE				
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE		
ARMY - FSP		PART NAME		MANUFACTURING		
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP140_DWG		
CHECKED BY R.Z.		DATE 11/29/11		PART NO.		
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100
				REV	SHEET 1 of 1	

4

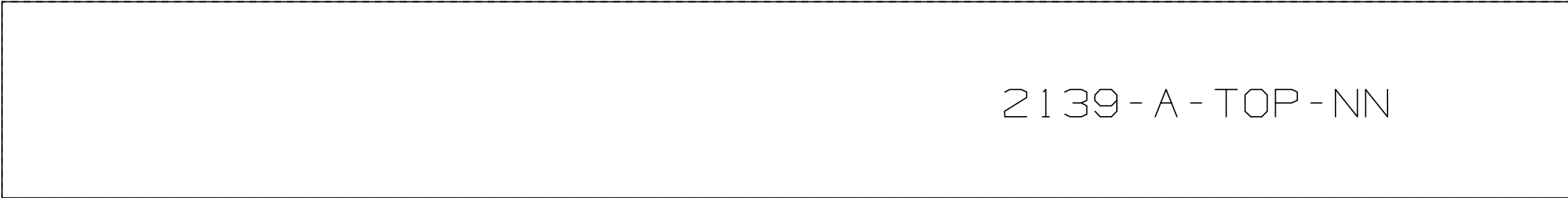
3

2

1

C

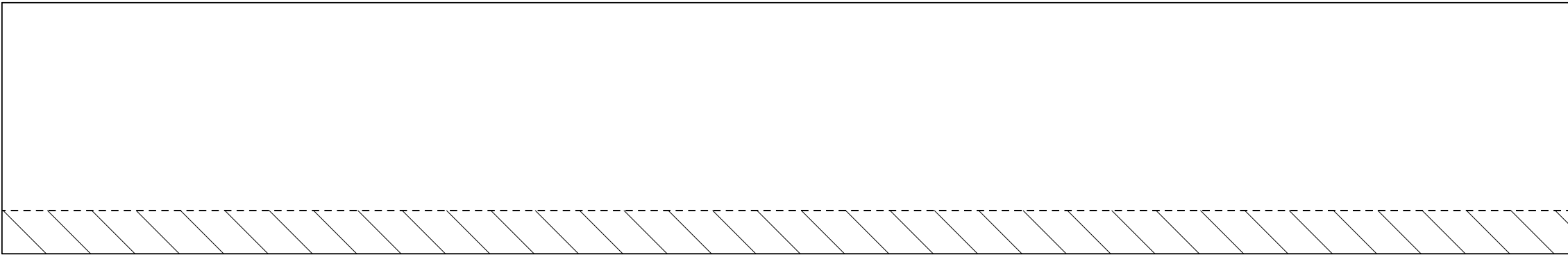
C



2139-A-TOP-NN

B

B



.6625

.1375

.800

.625

A

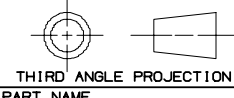
A

DECIMALS		TOLERANCES		ANGULAR	
1 PLACE	±.030			±0° 30'	
2 PLACE	±.010				
3 PLACE	±.005				
4 PLACE	±.0005				

FRACTIONS  
±1/16

UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL: 2139 AL

IP150  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>				
USAGE: ARMY - FSP		 THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING		
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C_TESTING_STRIPS_IP150_DWG		
CHECKED BY R.Z.		DATE 11/29/11		PART NO.		
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1

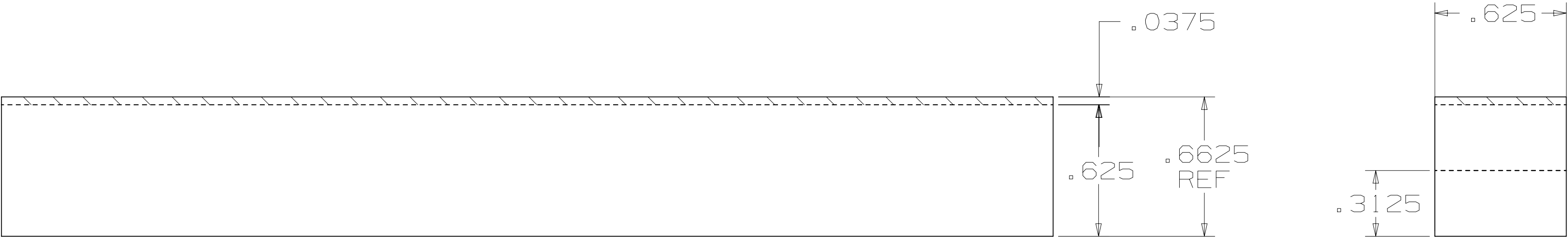
4

3

2

1

2139-A-TOP-NN



DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR ±0° 30'

FRACTIONS ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

UG CHANGE RESTRICTED		DO NOT SCALE				
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE		
ARMY - FSP		PART NAME		MANUFACTURING		
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP160_DWG		
CHECKED BY R.Z.		DATE 11/29/11		PART NO.		
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100
				REV	SHEET 1 of 1	

IP160  
DWG

4

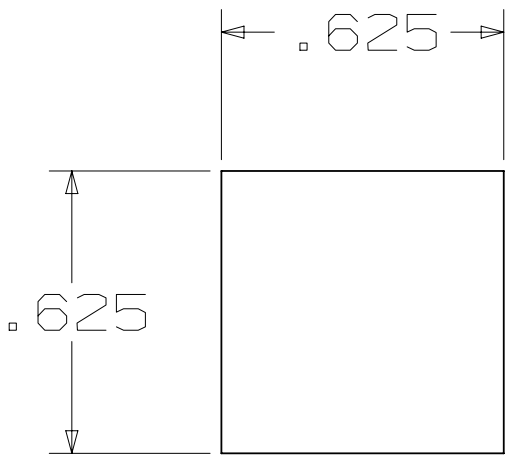
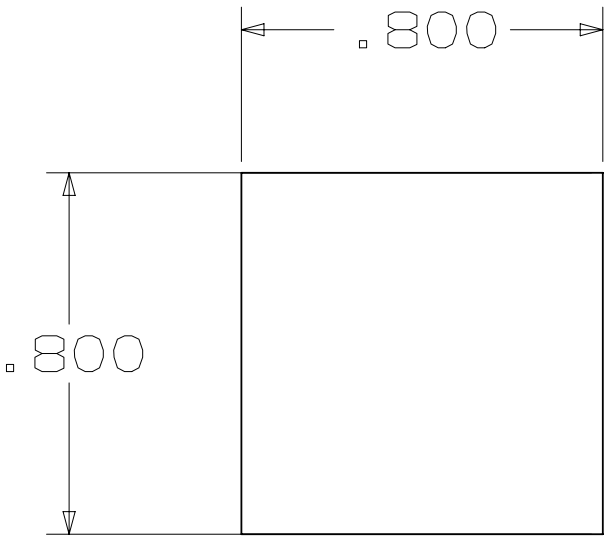
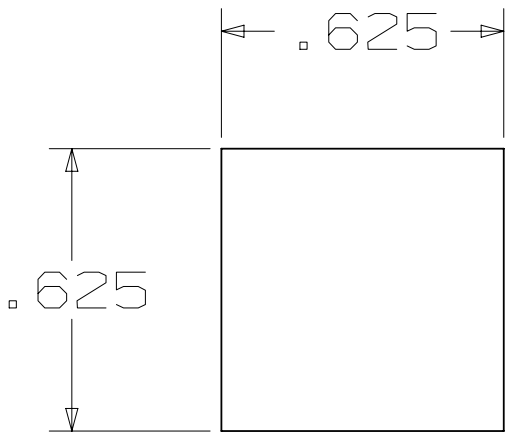
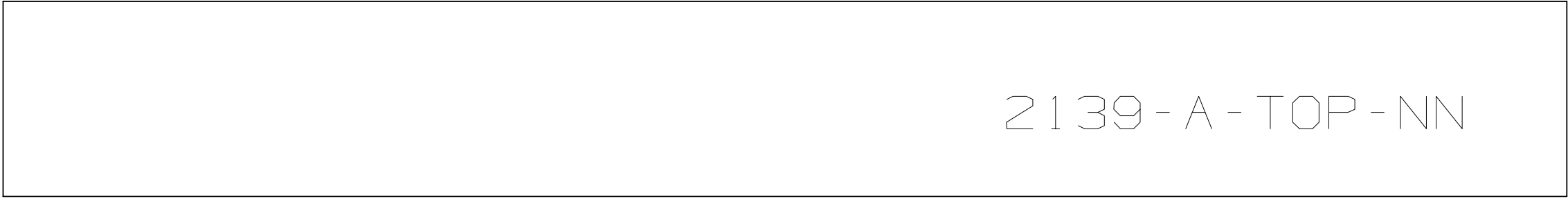
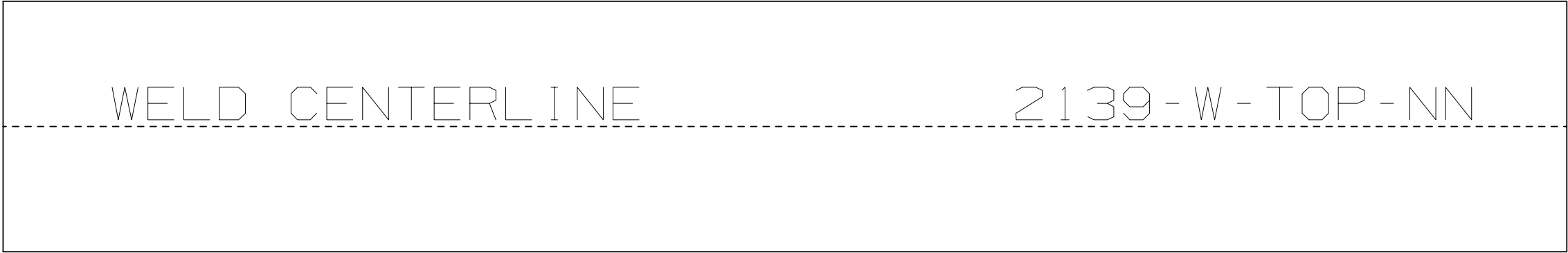
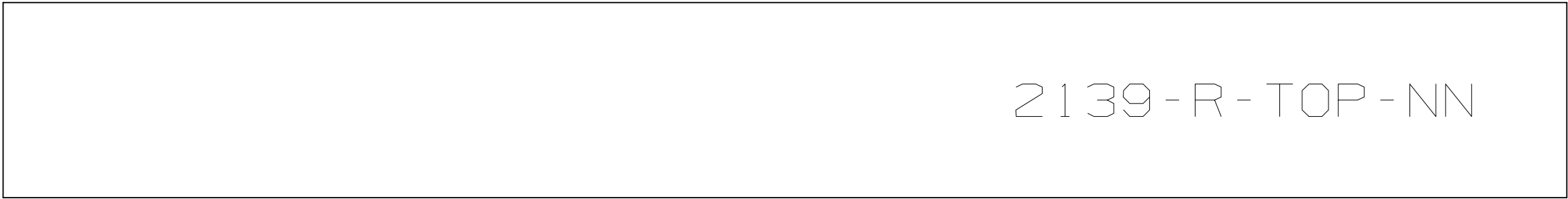
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2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

TOP VIEW OF 3 FINISHED BLOCKS



DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

FRACTIONS ±1/64


UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP170

DWG

UG CHANGE RESTRICTED		DO NOT SCALE					
USAGE:  ARMY-FSP				FOCUS: HOPE MANUFACTURING			
		THIRD ANGLE PROJECTION					
		PART NAME J C TESTING STRIPS					
DRAWN BY B.T.	DATE 11/29/11	DWG NO. J_C_TESTING_STRIPS_IP170-DWG					
CHECKED BY R.Z.	11/29/11	PART NO. X					
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1	

4

3

2

1

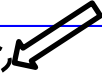
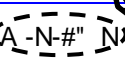
**Focus: HOPE Process routing/Shop traveler**Customer: **Southwest Research Institute**

Street Address:

City State Zip:

Stock: **3/4" x 3/4" x 4 1/2" FSW weld coupon (4 RET)**Part Number: **TAIT specimen**Description: **Johnson-Cook test specimens**

Revision:

Op No	Labor Code	Operation Description
		See 'Strips' Process Sheet for initial specimen extraction operations.
		<i>Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT,</i>
10		Confirm that all specimens are "6061-A" 
20	MILL	Circular interpolate end to .70 dia x .88
30	CNC	Center Drill, Turn square end round to .252/.254 x 1.5, .625 x 1.3; cut-off at 1.375
40		<b>Retrieve and label specimen</b>
		<b><i>DO NOT mark the final part in any way (laser, paint, etc.)</i></b>
		Individually <b>bag each part</b> and <b>mark each bag</b> "6061-A-N-#"  for Block Number and # for specimen
50	CNC	rechuck part against shoulder; turn to .252/.254 dia. x 1.5
60	CNC	Turn to .252/.254 dia. x 1.5; cut-off at 1.375
70		<b>Retrieve and label specimens</b>
80	MILL	Face mill each specimen to 1.3
90	MILL	Flip part and face mill 1.250
100		Bag and Label



4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

C

C

B

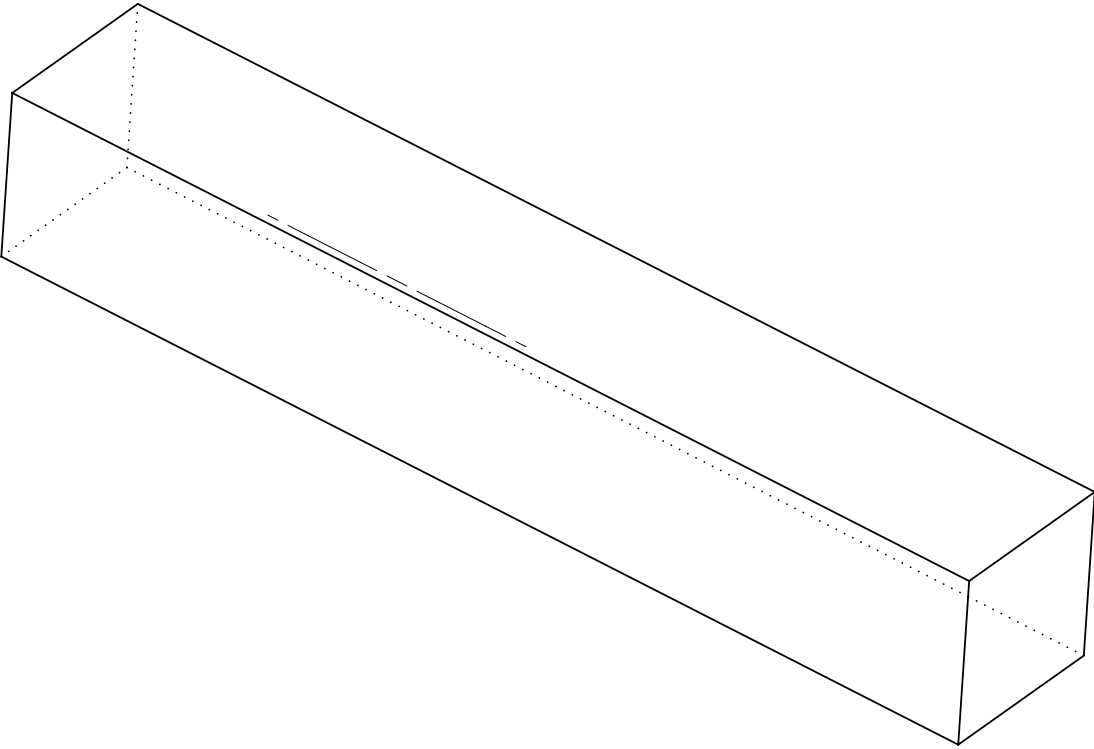
B

A

A

MMMM - X - TOP - NN

4.50  
REF



.75  
REF

.75  
REF

IP10  
DWG

DECIMALS                      TOLERANCES                      ANGULAR

1 PLACE..... ±.030                      ±0° 30'

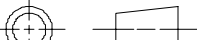
2 PLACE..... ±.010

3 PLACE..... ±.003                      FRACTIONS                      ±1/64

4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

MATERIAL :

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>					
USAGE:  ARMY-FSP				<b>FOCUS CODE</b> <b>MANUFACTURING</b>			
		THIRD ANGLE PROJECTION					
PART NAME		T A I T SPECIMEN					
DRAWN BY B.T.		DATE 10/5/11		DWG NO. T_A_I_T_SPECIMEN_IP10_DWG			
CHECKED BY R.Z.		10/5/11		PART NO.			
RELEASED BY		SCALE N/A		SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1

4

3

2

1

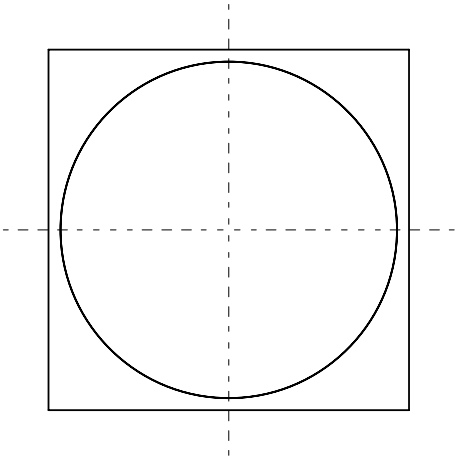
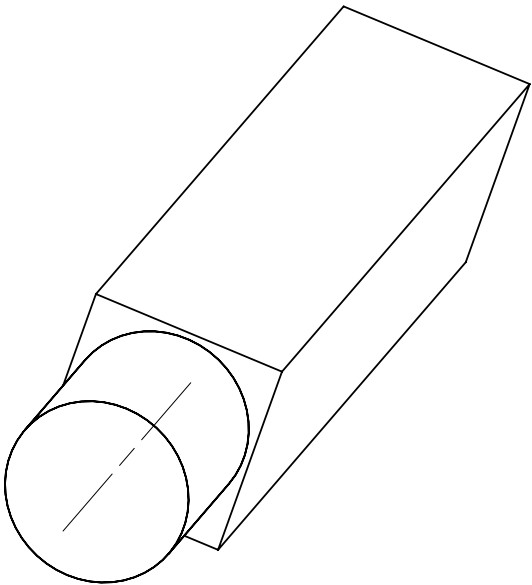
4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS                      TOLERANCES                      ANGULAR

1 PLACE..... ±.030                      ±0° 30 '

2 PLACE..... ±.010

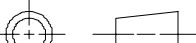
3 PLACE..... ±.003                      FRACTIONS

4 PLACE..... ±.0005                      ±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP20  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE:  ARMY FSP				FOCUS CODE MANUFACTURING	
		THIRD ANGLE PROJECTION			
		PART NAME T A I T SPECIMEN			
DRAWN BY B.T.	DATE 9/27/11	DWG NO. T_A_I_T_SPECIMEN_IP20_DWG			
CHECKED BY R.Z.	9/27/11	PART NO.			
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

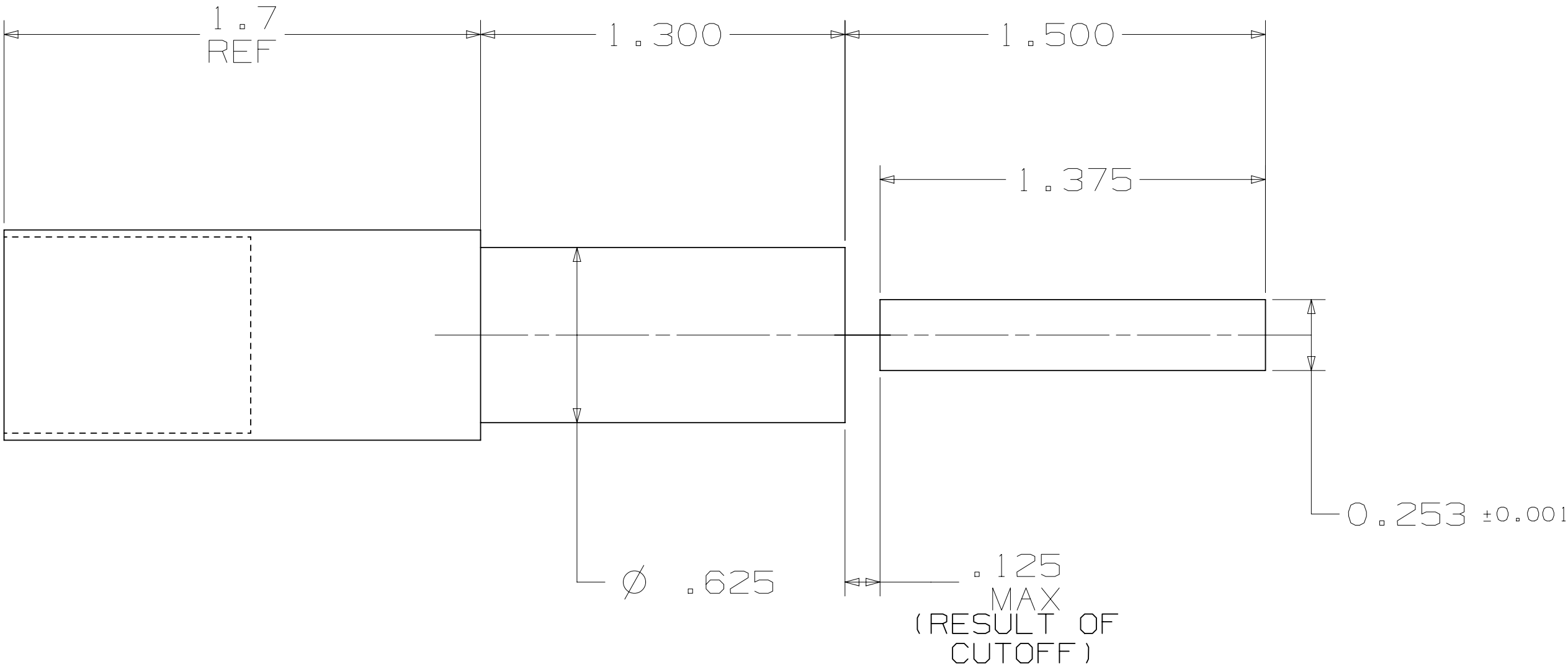
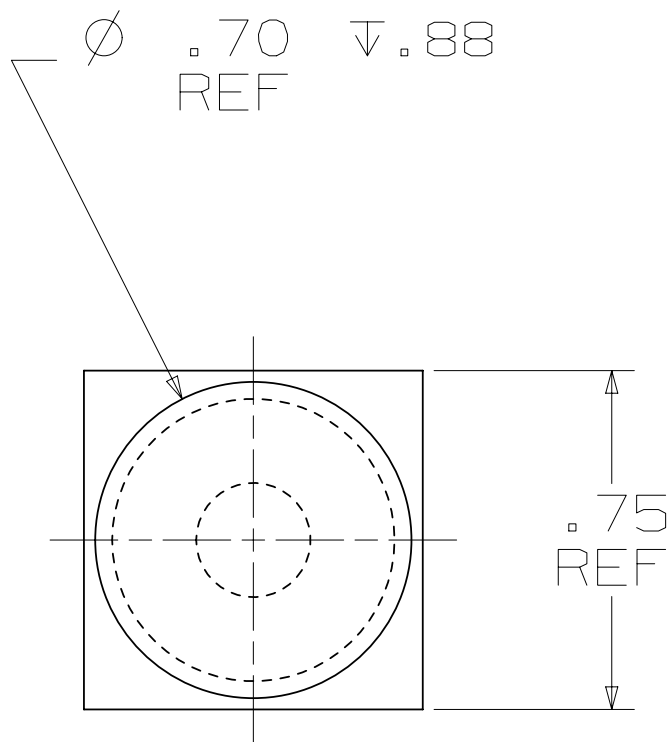
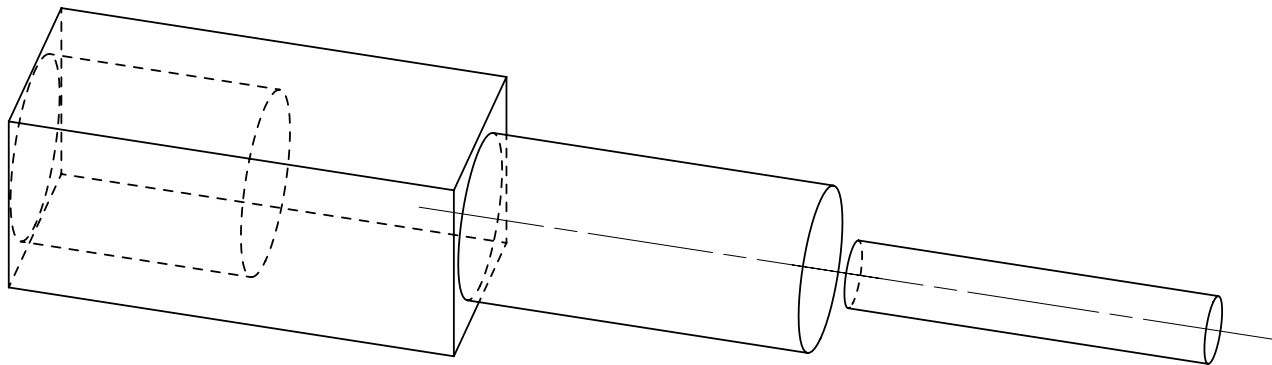
4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS      TOLERANCES      ANGULAR

1 PLACE..... ±.030      ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.005      FRACTIONS

4 PLACE..... ±.0005      ±1/64

UNLESS OTHERWISE SPECIFIED

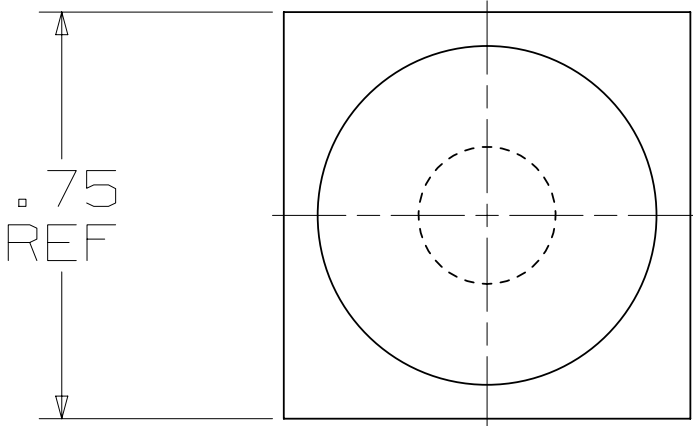
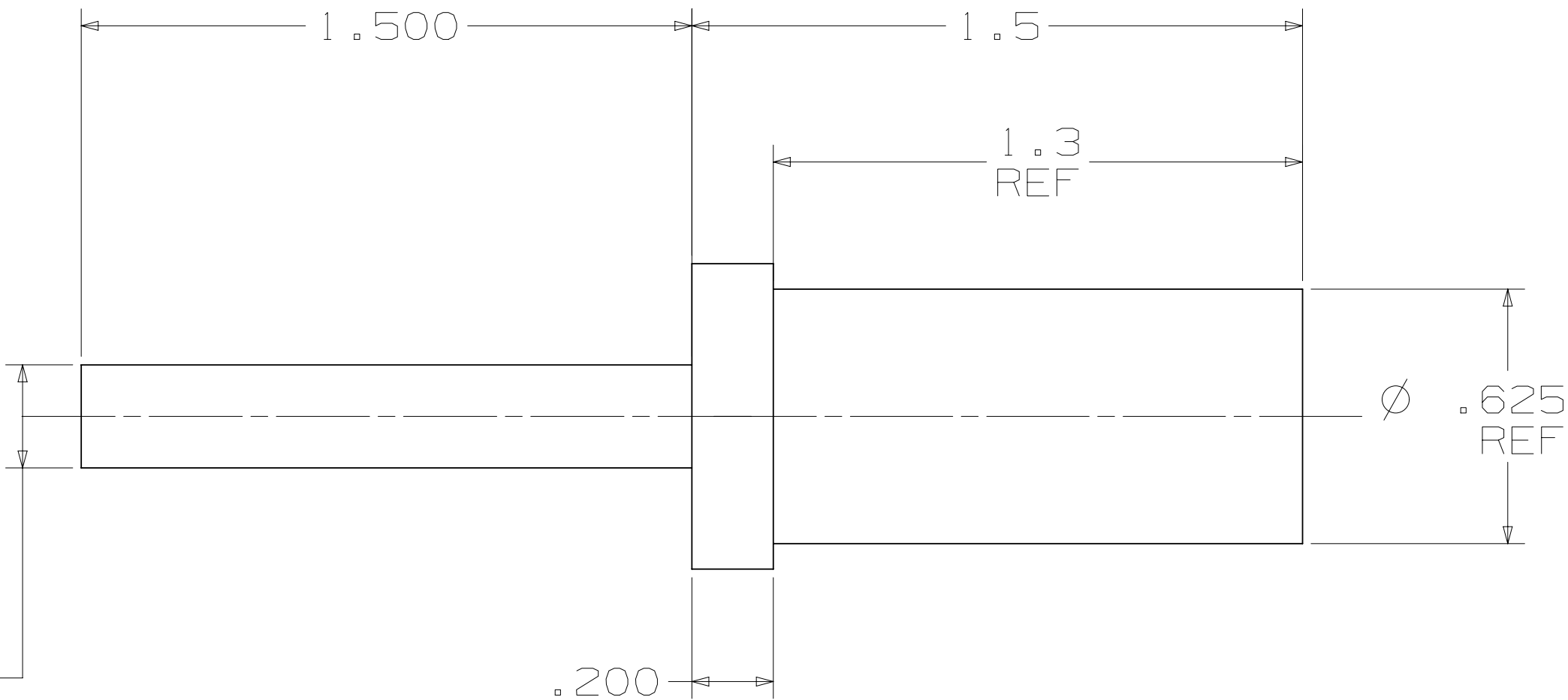
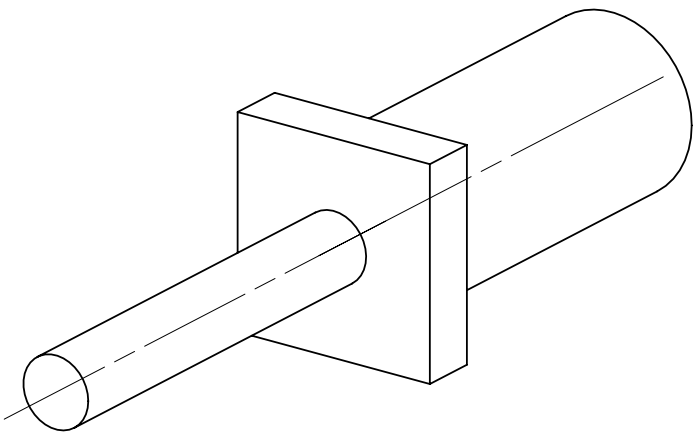
BREAK ALL SHARP EDGES

MATERIAL:

IP30  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE	
ARMY-FSP		PART NAME		MANUFACTURING	
DRAWN BY B.T.		DATE 10/5/11		DWG NO. T_A_I_T_SPECIMEN_IP30_DWG	
CHECKED BY R.Z.		DATE 10/5/11		PART NO. X	
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C
				DWG LEVEL 100	REV
				SHEET 1 OF 1	

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS                      TOLERANCES                      ANGULAR

1 PLACE..... ±.030                      ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.005                      FRACTIONS                      ±1/64

4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL:

IP50  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE	
ARMY-FSP				MANUFACTURING	
DRAWN BY B.T.		DATE 10/6/11		DWG NO.	
CHECKED BY R.Z.		DATE 10/6/11		PART NO.	
RELEASED BY		UNITS INCHES		SCALE N/A	
				SIZE C	
				DWG LEVEL 100	
				REV X	
				SHEET 1 of 1	

4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

C

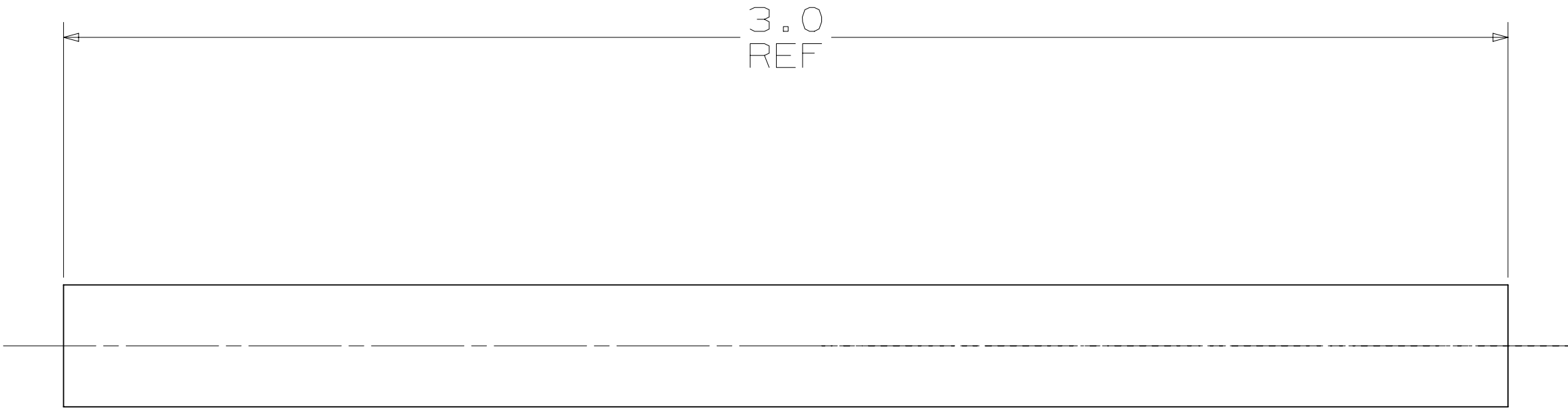
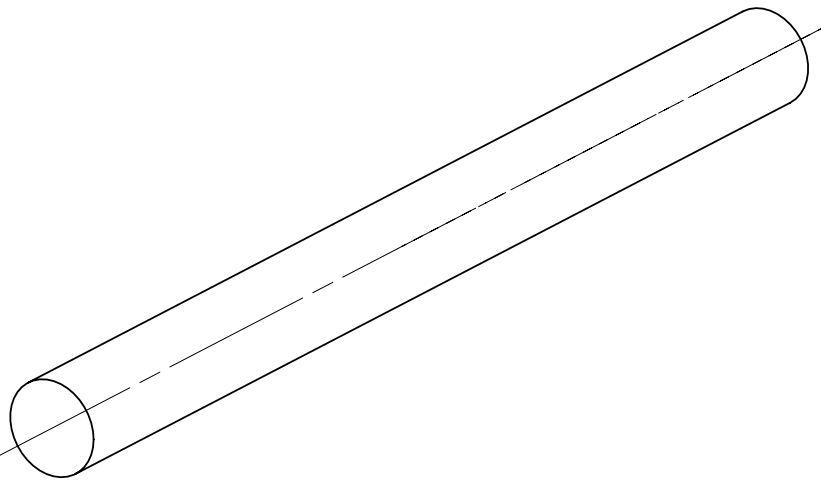
C

B

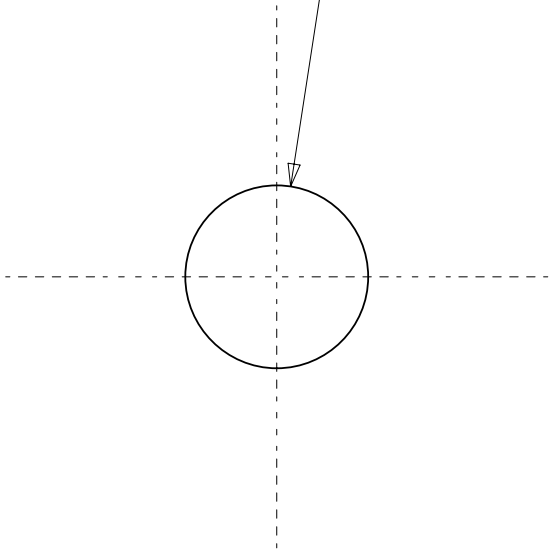
B

A

A



Ø .253 ±0.001



DECIMALS                      TOLERANCES                      ANGULAR  
1 PLACE..... ±.030                      ±0° 30'  
2 PLACE..... ±.010  
3 PLACE..... ±.005                      FRACTIONS  
4 PLACE..... ±.0005                      ±1/64

UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL:

IP60A  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE					
USAGE: ARMY-FSP		THIRD ANGLE PROJECTION 		FOCUS CODE MANUFACTURING			
DRAWN BY B.T.		DATE 9/27/11		DWG NO. T_A_I_T_SPECIMEN_IP60A_DWG			
CHECKED BY R.Z.		DATE 9/27/11		PART NO. X			
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

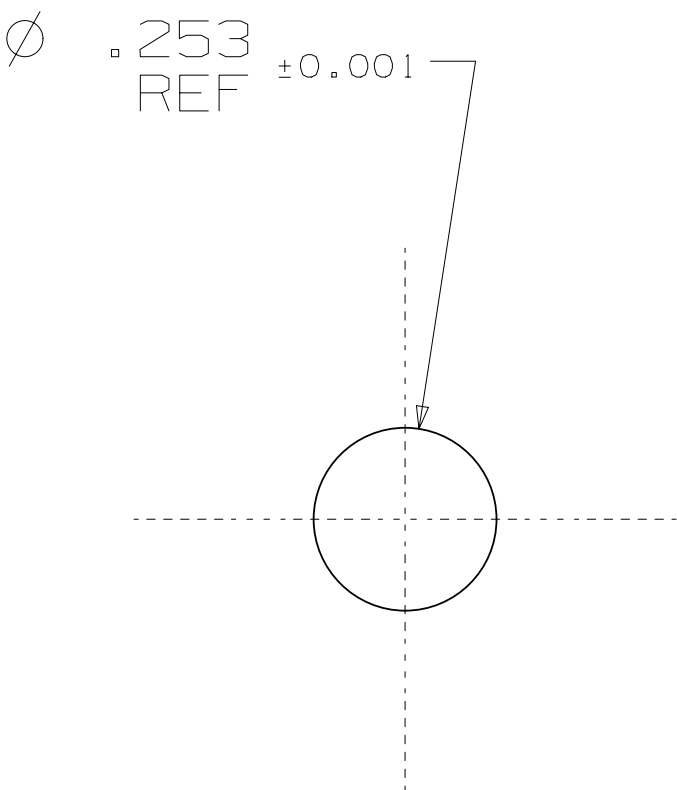
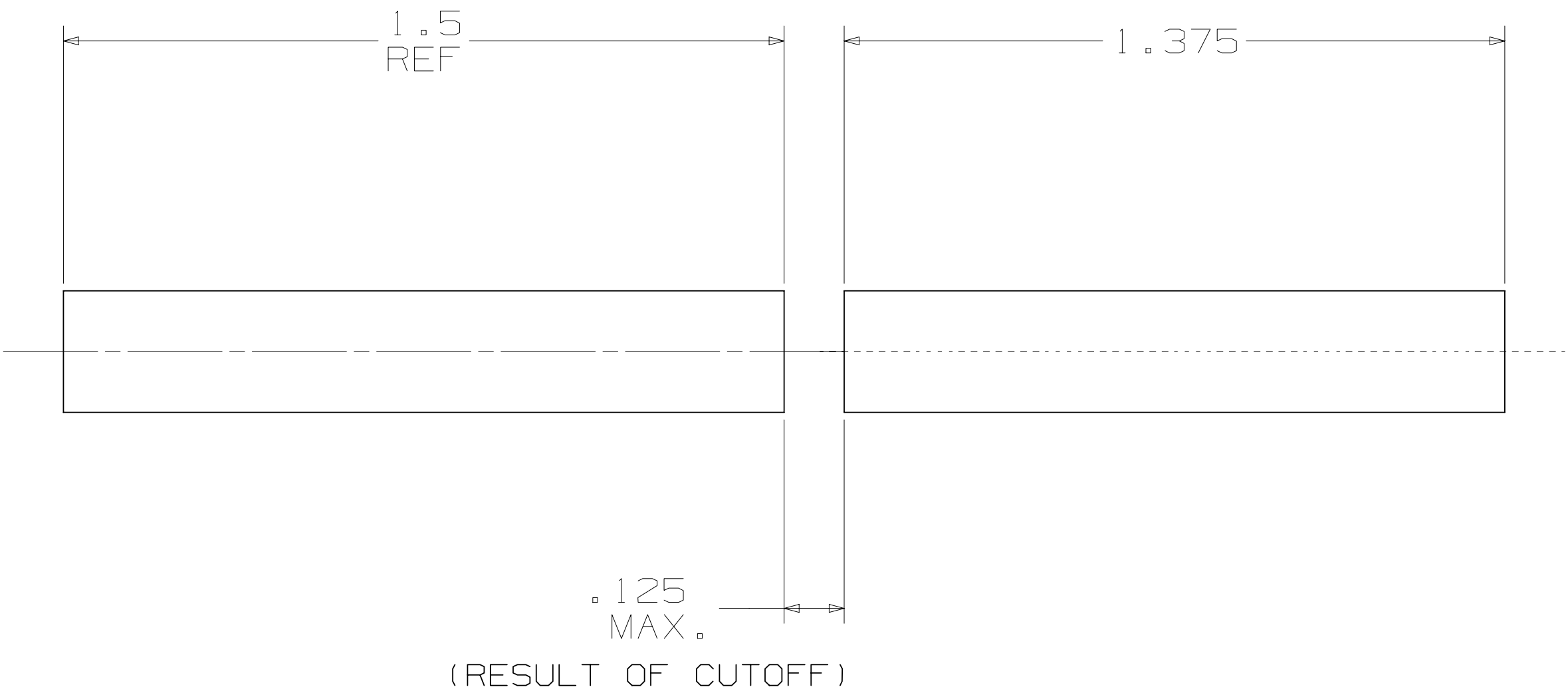
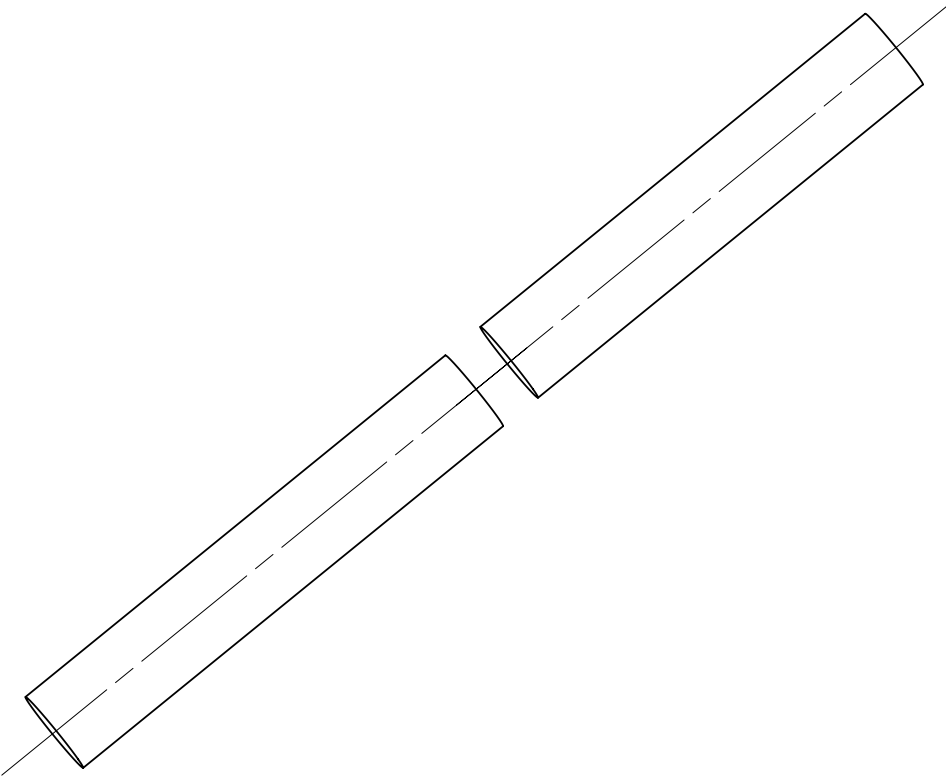
4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS                      TOLERANCES                      ANGULAR

1 PLACE..... ±.030                      ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.005                      FRACTIONS                      ±1/64

4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

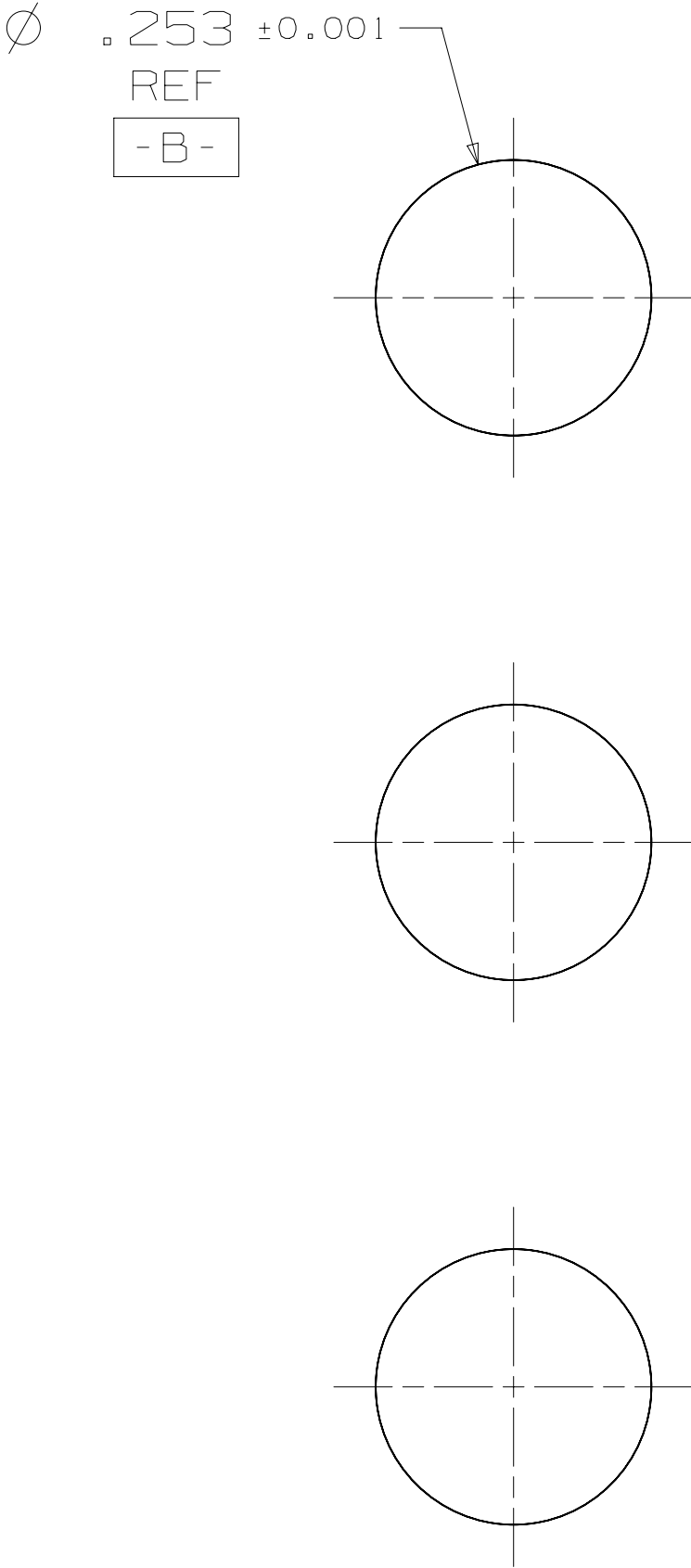
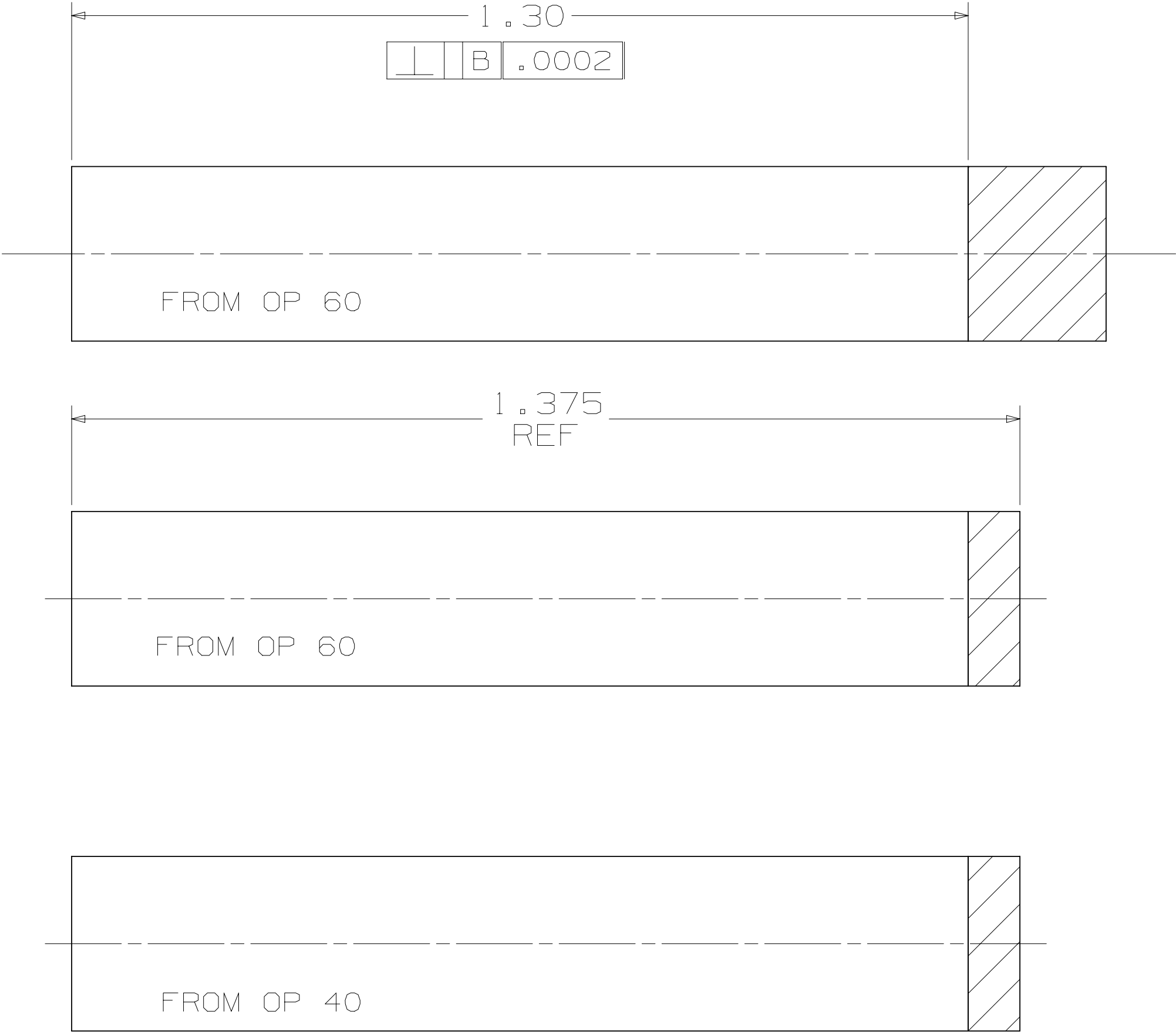
BREAK ALL SHARP EDGES

MATERIAL:

IP60B  
DWG

<i>UG</i> CHANGE RESTRICTED		<i>DO NOT SCALE</i>			
USAGE: ARMY-FSP		 THIRD ANGLE PROJECTION		 FOCUS CODE	
DRAWN BY B.T.		DATE 10/6/11		DWG NO. T_A_I_T_SPECIMEN_IP60B_DWG	
CHECKED BY R.Z.		DATE 10/6/11		PART NO. X	
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
		REV	SHEET 1 of 1		

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

FRACTIONS ±1/64

UNLESS OTHERWISE SPECIFIED

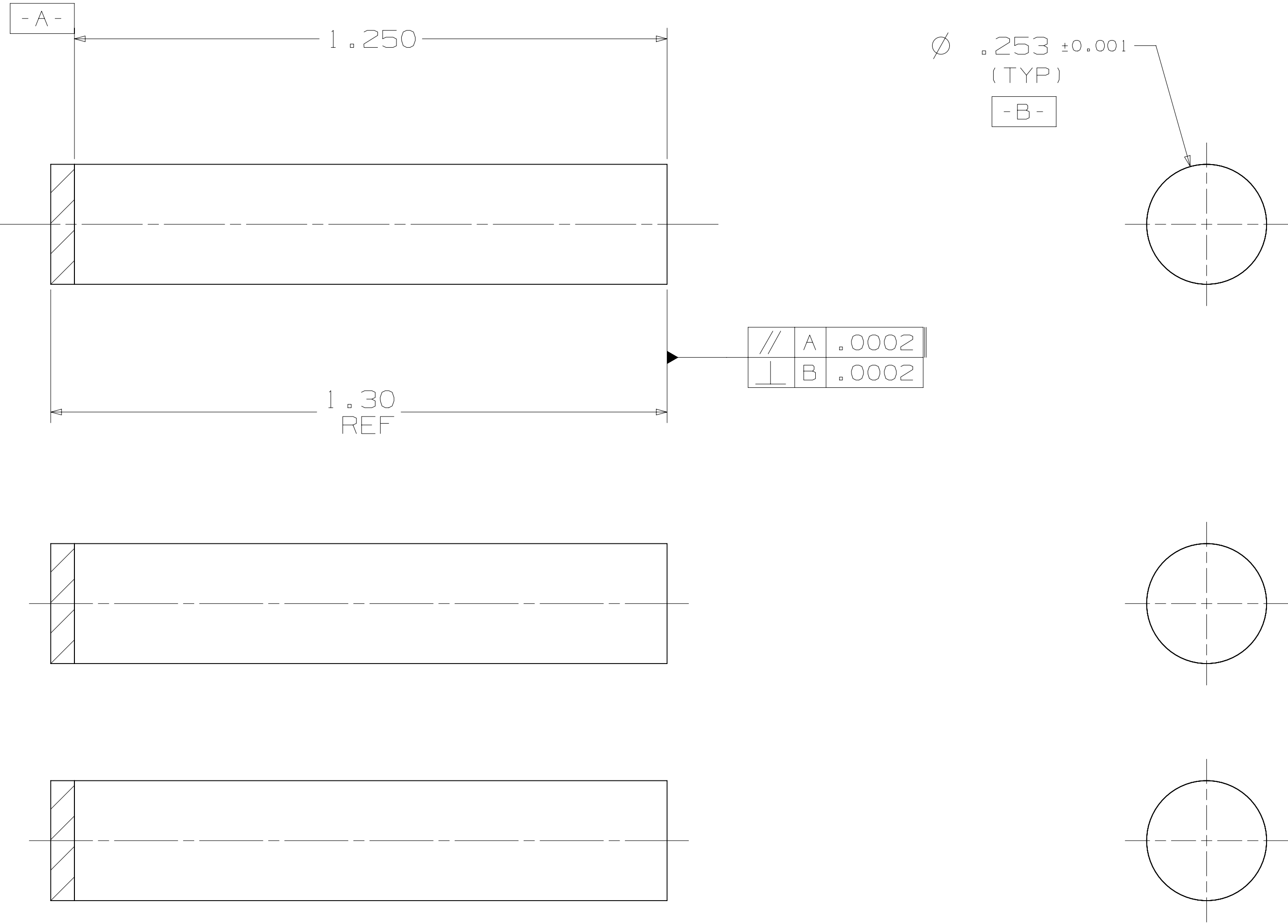
BREAK ALL SHARP EDGES

MATERIAL:

UG CHANGE RESTRICTED		DO NOT SCALE	
USAGE: ARMY-FSP		THIRD ANGLE PROJECTION PART NAME T A I T SPECIMEN	
DRAWN BY B.T. DATE 10/7/11		DWG NO. T_A_I_T_SPECIMEN_IP80_DWG	
CHECKED BY R.Z. DATE 10/7/11		PART NO. X	
RELEASED BY UNITS INCHES		SCALE N/A SIZE C DWG LEVEL 100 REV SHEET 1 of 1	

IP80  
DWG

COMPLETION OF PROCESS RESULTS IN 3 PIECES



DECIMALS	TOLERANCES	ANGULAR
1 PLACE.....	±.030	±0° 30'
2 PLACE.....	±.010	
3 PLACE.....	±.005	FRACTIONS
4 PLACE.....	±.0005	±1/64

UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL :

IP90  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE : ARMY-FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 10/7/11		DWG NO. T_A_I_T_SPECIMEN_IP90_DWG	
CHECKED BY R.Z.		DATE 10/7/11		PART NO. X	
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
				REV	SHEET 1 of 1



**Focus: HOPE Process routing/Shop traveler**

Customer: <b>Southwest Research Institute</b>		
Street Address:		
City State Zip:		
Stock: <b>3/4 x 3/4 x 4 1/2 coupon (8)</b>		
Part Number: <b>A-250in_SmoothTensile</b>		
Description: <b>Johnson-Cook test specimen</b>		
Revision:		
Op No	Labor Code	Operation Description
		See 'Strips' Process Sheet for initial specimen extraction operations.
		Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT,
10		Confirm that all material blocks are marked "6061-W"
20	Mill	Square mill end, round (circular interpolate) end to 0.70 dia x 0.88 and center drill
30	Laser	Mark end "61W-#" (where # = 1 thru 8)
40	Mazak	center drill, rough contour turn, final contour turn, single point thread
50	Laser	Mark end "61W-#" (where # = 1 thru 8)
60		Individually bag each part
70		Label Bags
80		Polish Longitudinally
90	Mazak	Cover polished area with rubber hose. Cut-off to final length 3.000

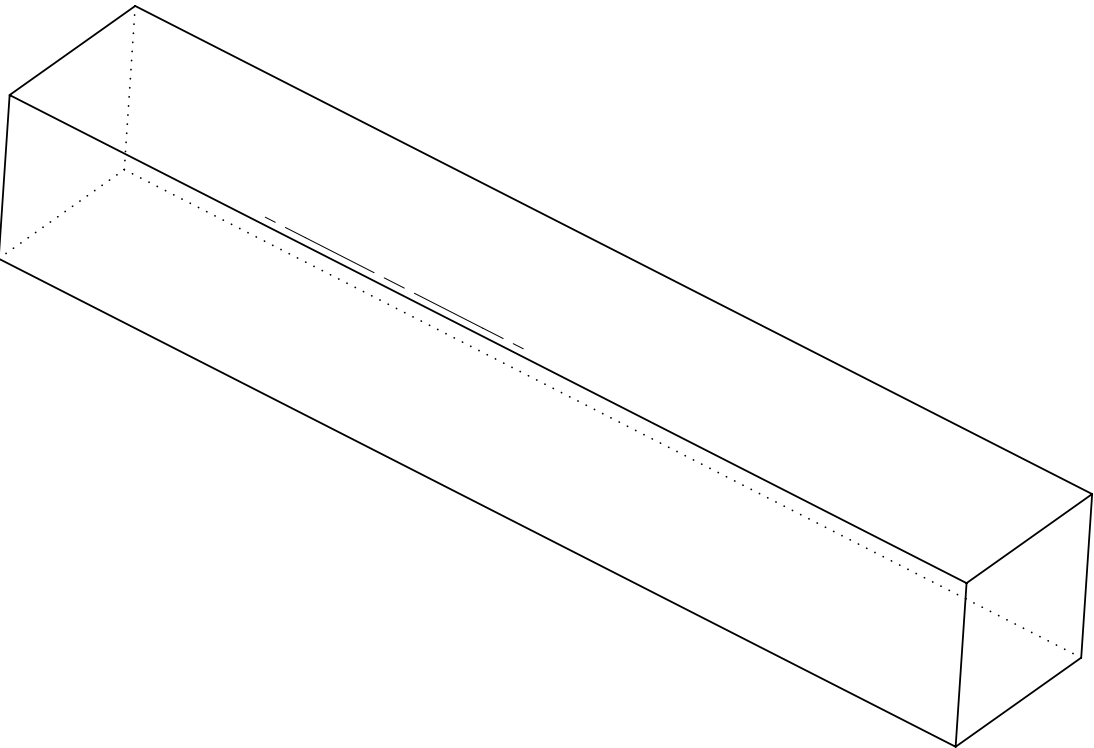
4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



MMMM - X - TOP - NN

4 .50  
REF

.75  
REF

.75  
REF

IP10  
DWG

DECIMALS                      TOLERANCES                      ANGULAR

1 PLACE..... ±.030                      ±0° 30'

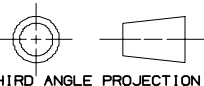

2 PLACE..... ±.010

3 PLACE..... ±.003                      FRACTIONS                      ±1/64

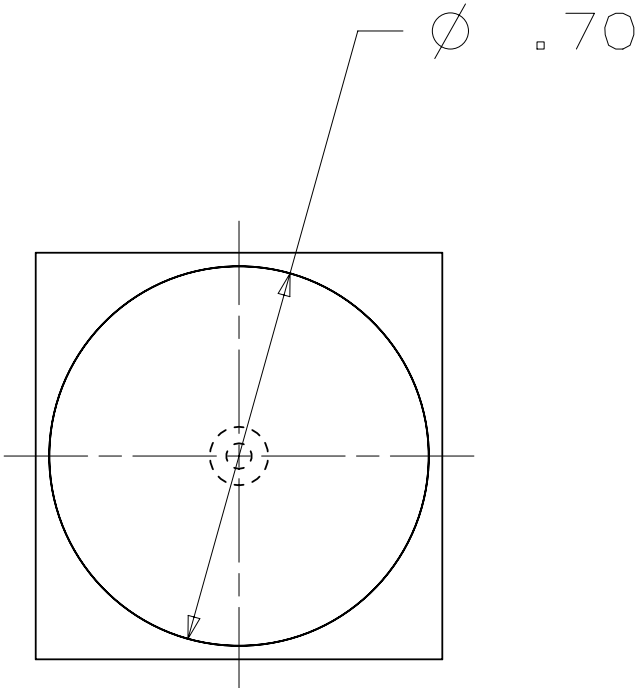
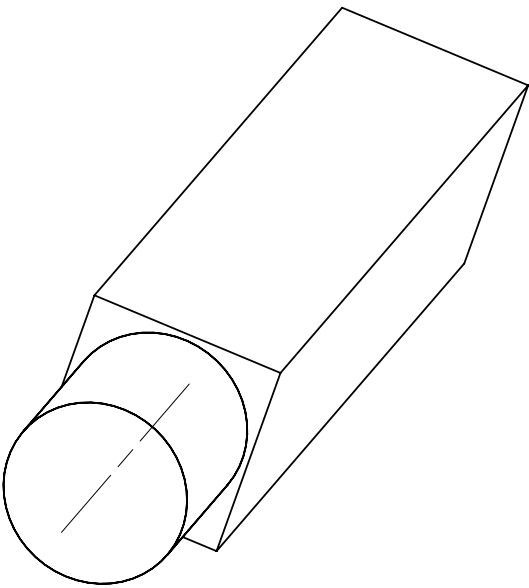
4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

MATERIAL :

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>			
USAGE:  ARMY - FSP		 THIRD ANGLE PROJECTION		 FOCUS CODE MANUFACTURING	
		PART NAME A 250IN SMOOTH TENSILE			
		PART NO. A_250IN_SMOOTHTENSILE_IP10_DWG			
DRAWN BY B.T.	DATE 10/4/11				
CHECKED BY R.Z.	10/4/11				
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV
		SHEET 1 of 1			

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS                      TOLERANCES                      ANGULAR

1 PLACE..... ±.030                      ±0° 30 '

2 PLACE..... ±.010

3 PLACE..... ±.003                      FRACTIONS                      ±1/64

4 PLACE..... ±.0005

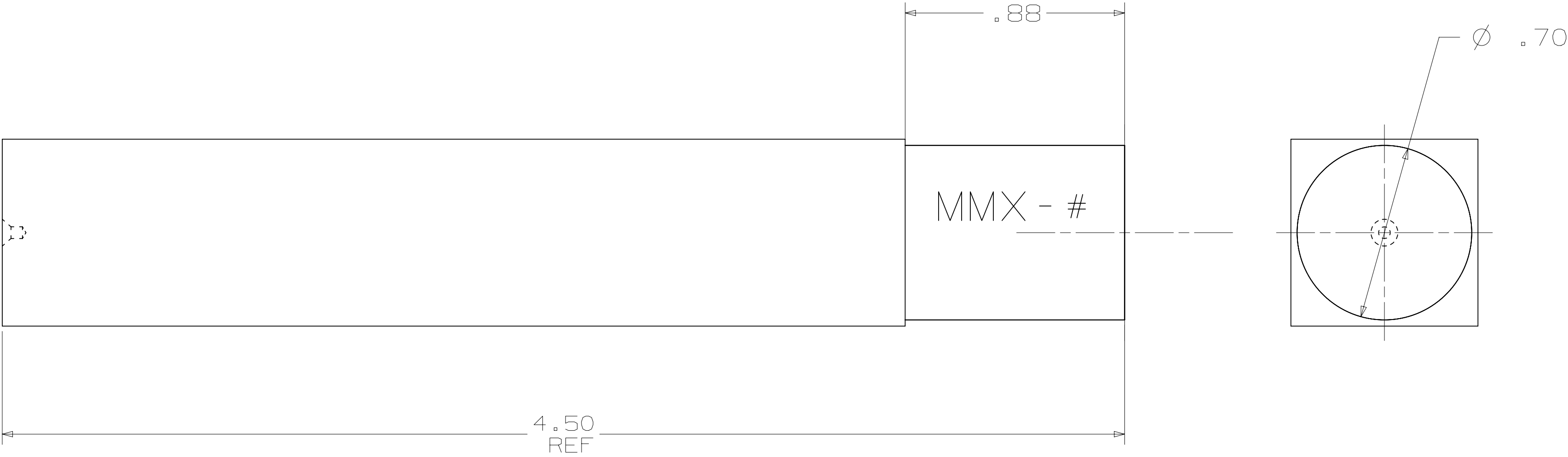
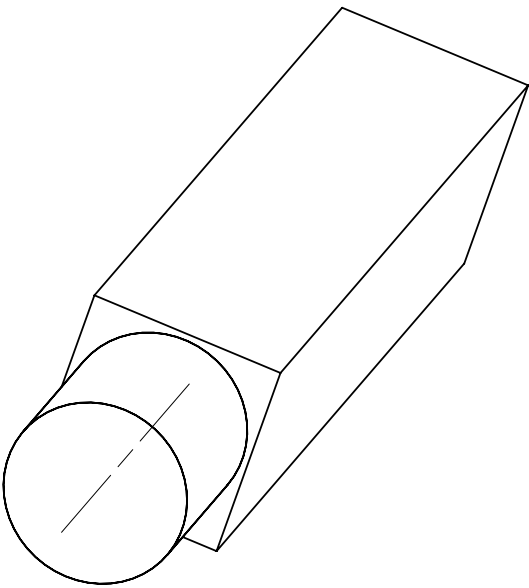
UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP20  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>			
USAGE: ARMY FSP				<b>FOCUS CODE</b> MANUFACTURING	
DRAWN BY B.T.		DATE 10/4/11		DWG NO. A_250IN_SMOOTH TENSILE_IP20_DWG	
CHECKED BY R.Z.		10/4/11		PART NO.	
RELEASED BY				SCALE N/A	SIZE C
				DWG LEVEL 100	REV
				SHEET 1 of 1	

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30 '

2 PLACE..... ±.010


3 PLACE..... ±.003 FRACTIONS

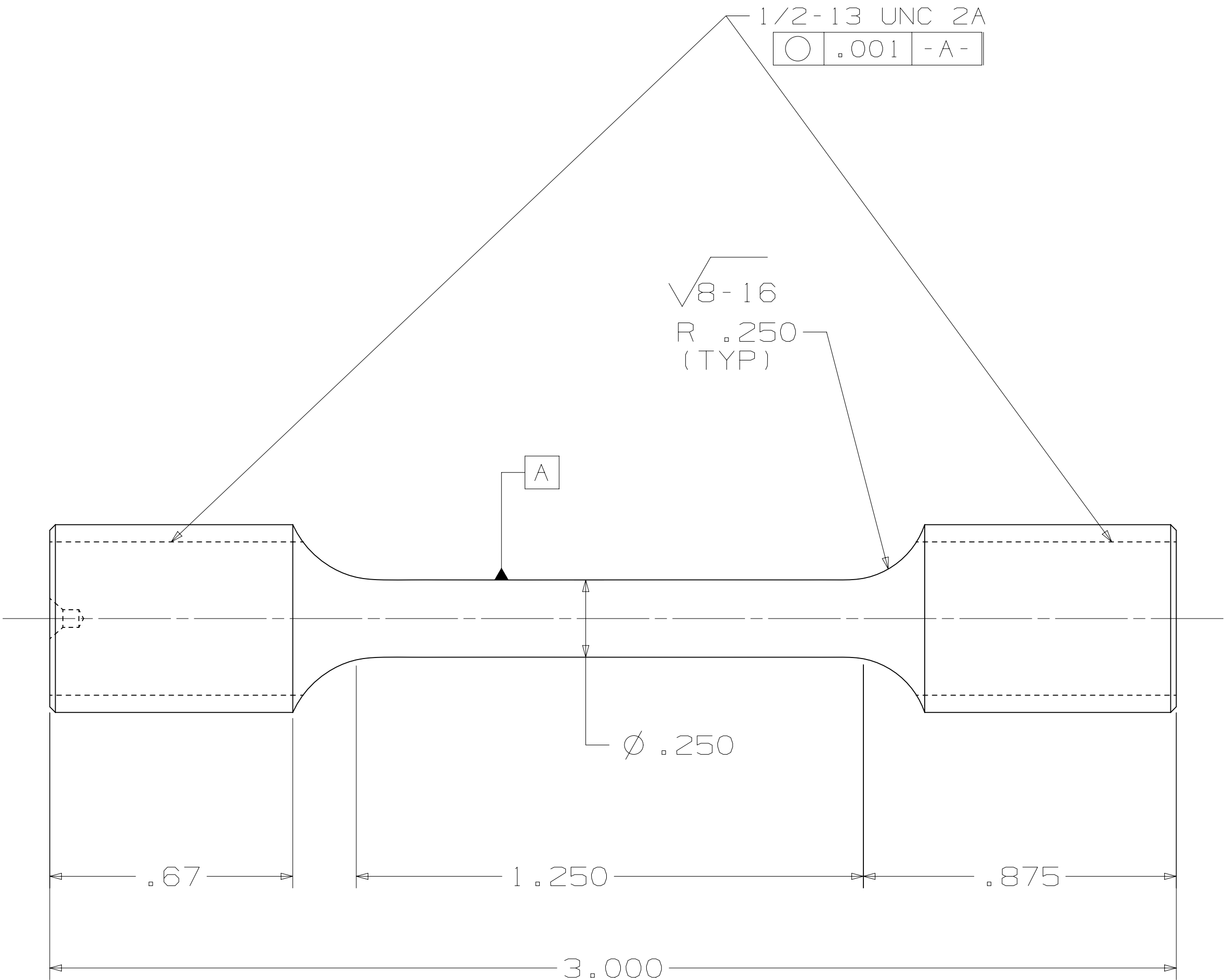
4 PLACE..... ±.0005 ±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP30  
DWG

UG CHANGE RESTRICTED			DO NOT SCALE			
USAGE:  ARMY FSP					FOCUS: HDPE MANUFACTURING	
			THIRD ANGLE PROJECTION			
			PART NAME A 250IN SMOOTH TENSILE			
DRAWN BY B.T.		DATE 10/4/11	DWG NO. A_250IN_SMOOTHTENSILE_IP30_DWG			
CHECKED BY R.Z.		10/4/11	PART NO.			
RELEASED BY			SCALE N/A	SIZE C	DWG LEVEL 100	REV
			SHEET 1 of 1			



1/2-13 UNC 2A  
Ø .001 -A-

√8-16  
R .250  
(TYP)

A

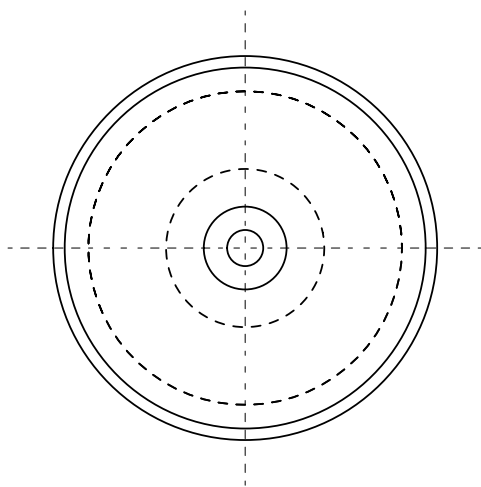
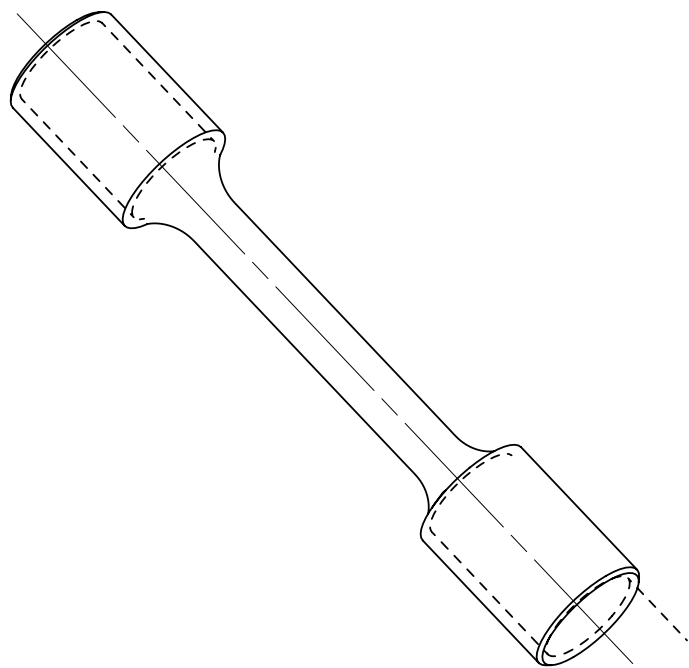
Ø .250

.67

1.250

.875

3.000



TOLERANCES (INCH)  
DECIMALS

1 PLACE..... ±.030  
2 PLACE..... ±.010  
3 PLACE..... ±.003  
4 PLACE..... ±.0005

ANGULAR  
±0° 30'

FRACTIONS  
±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL:

IP40  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE	
ARMY FSP		PART NAME		MANUFACTURING	
DRAWN BY B.T.		DATE 10/4/11		DWG NO. A_250IN_SMOOTHTENSILE_IP40_DWG	
CHECKED BY R.Z.		10/4/11		PART NO.	
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 OF 1

4

3

2

1

C

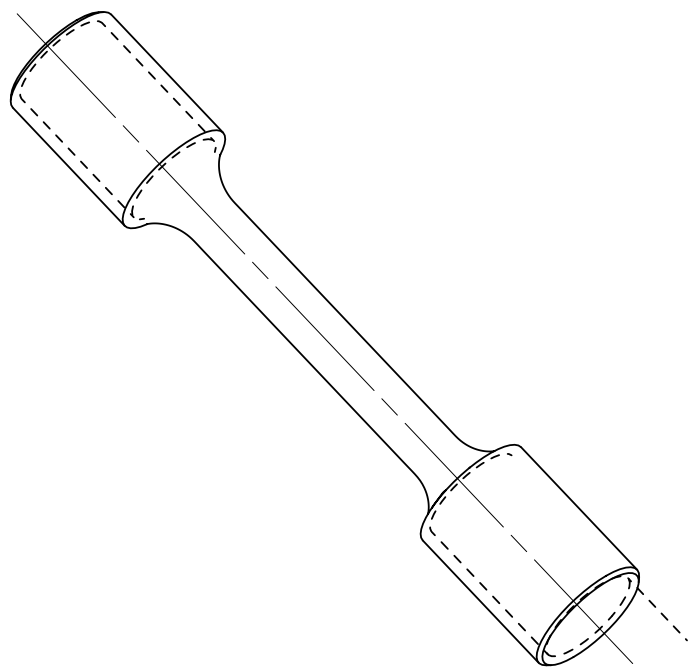
C

B

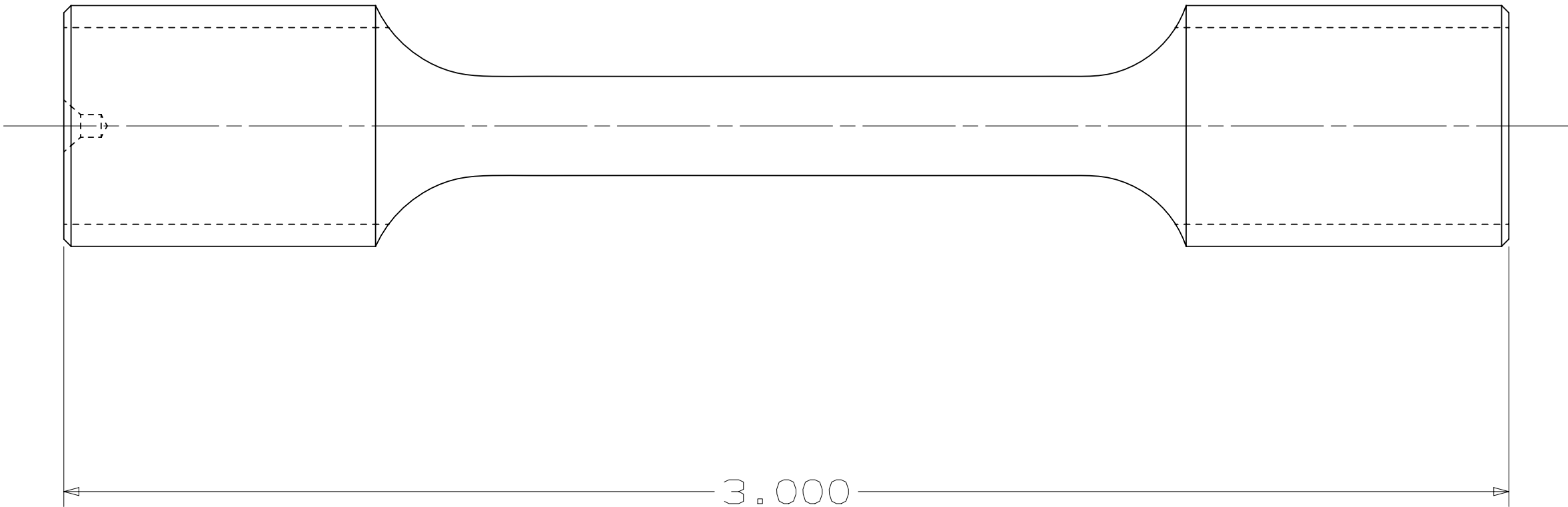
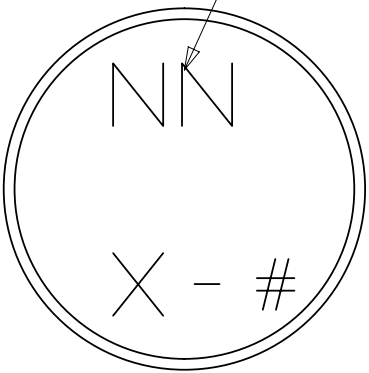
B

A

A



\*MARK LOCATION\*



TOLERANCES (INCH)  
DECIMALS

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.003
- 4 PLACE..... ±.0005

ANGULAR  
±0° 30'

FRACTIONS  
±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL:

IP50  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE	
ARMY FSP		PART NAME		MANUFACTURING	
DRAWN BY B.T.		DATE 10/4/11		DWG NO. A_250IN_SMOOTHTENSILE_IP50_DWG	
CHECKED BY R.Z.		10/4/11		PART NO.	
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

**Focus: HOPE Process routing/Shop traveler**Customer: **TACOM Warren**

Street Address:

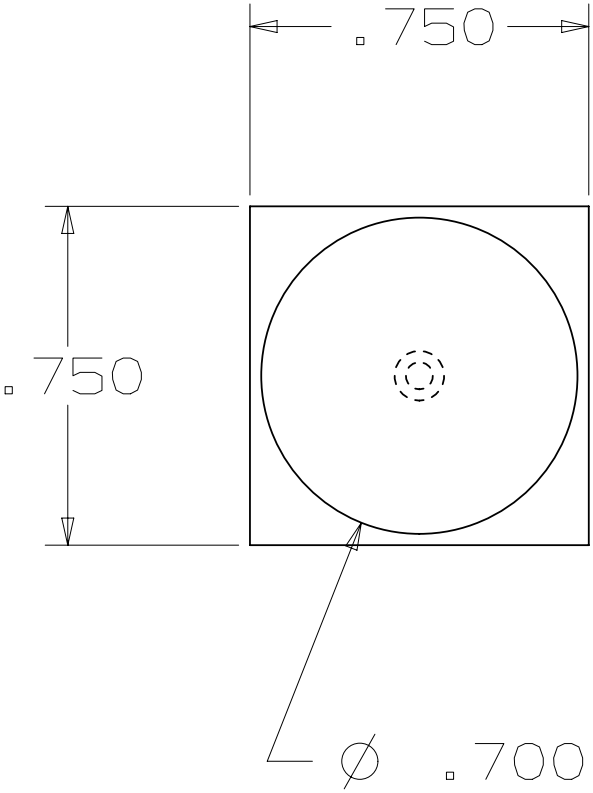
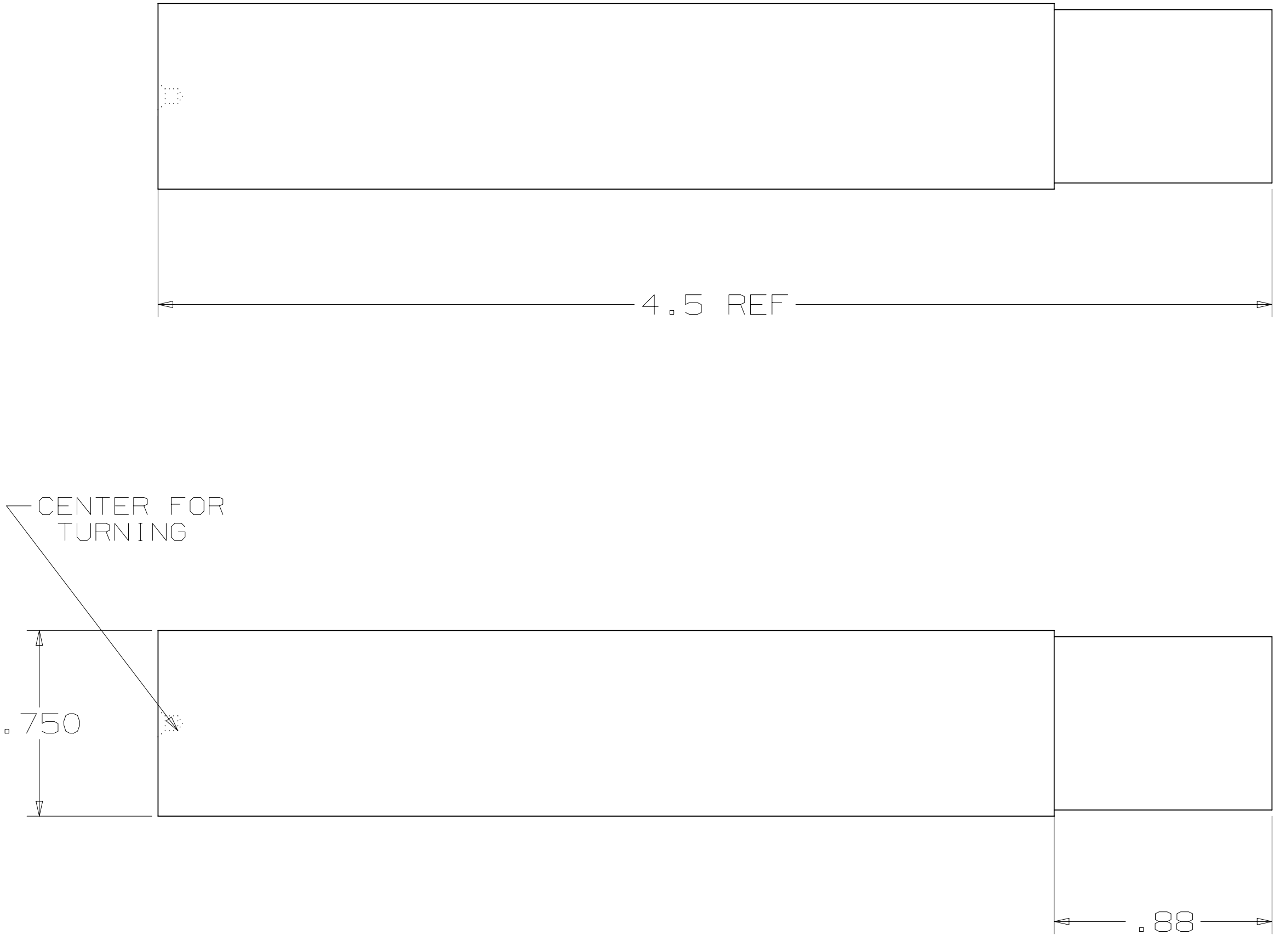
City State Zip:

Stock: **.650 x 2.525" FSW weld coupon (4)**Part Number: **.375 Compression Specimen (SHPBC)**Description: **Split Hopkinson Pressure Bar test specimen**

Revision:

Op No	Labor Code	Operation Description
		See Torsion Process Sheet for initial specimen extraction operations.
		Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT,
10		Confirm that all material blocks are marked "6061-W"
20	CNC	Turn to 0.375 dia x 1.5
30	CNC	Turn to .375 dia.x 1.325; cut-off at 1.2
		DO NOT mark the final part in any way (laser, paint, etc.)
40		Individually bag each part and mark each bag "61W"
50	CNC	Face mill end; clean surface
60	CNC	Face mill end to final length

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES

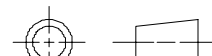
1 PLACE.....	±.030
2 PLACE.....	±.010
3 PLACE.....	±.005
4 PLACE.....	±.0005

ANGULAR  
±0° 30'

FRACTIONS  
±1/16

UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL :

IP10  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>											
USAGE:  ARMY - FSP				FOCUS: <b>CODE</b> <b>MANUFACTURING</b>									
		THIRD ANGLE PROJECTION		PART NAME  SHPBC									
DRAWN BY B.T.		DATE 11/2/11		DWG NO.  SHPBC_IP10_DWG									
CHECKED BY R.Z.		DATE 11/2/11		PART NO.									
RELEASED BY		UNITS INCHES		SCALE N/A		SIZE C		DWG LEVEL 100		REV		SHEET 1 of 1	



4

3

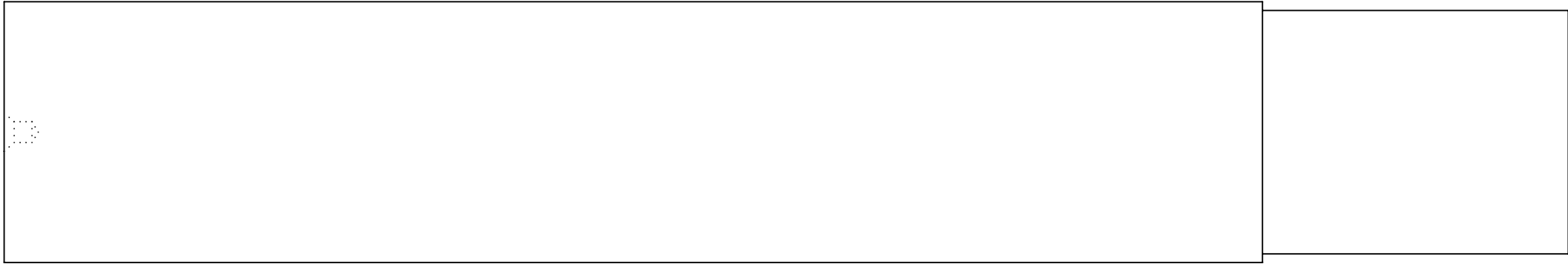
2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

C

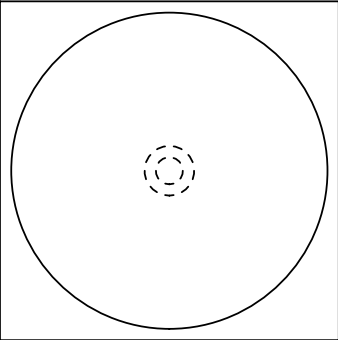
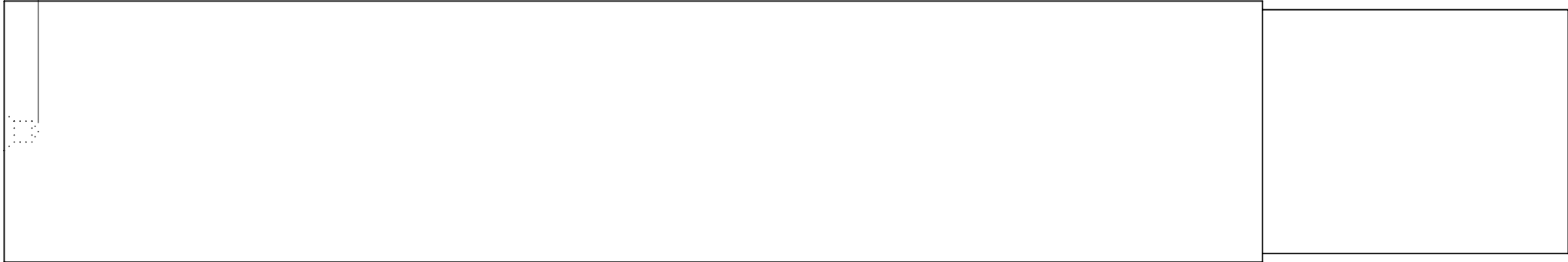
C



.098

B

B



A

A

DECIMALS TOLERANCES

1 PLACE..... ±.030  
2 PLACE..... ±.010  
3 PLACE..... ±.005  
4 PLACE..... ±.0005

ANGULAR  
±0° 30'

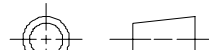
FRACTIONS  
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL :

IP20  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE						
USAGE :				Focus: RUDE				
ARMY - FSP				MANUFACTURING				
		THIRD ANGLE PROJECTION						
		PART NAME						
		SHPBC						
DRAWN BY		DATE		DWG NO.				
B.T.		11/3/11		SHPBC_IP20_DWG				
CHECKED BY		DATE		PART NO.				
R.Z.		11/3/11						
RELEASED BY		UNITS		SCALE	SIZE	DWG LEVEL	REV	SHEET 1 of 1
		INCHES		N/A	C	100		

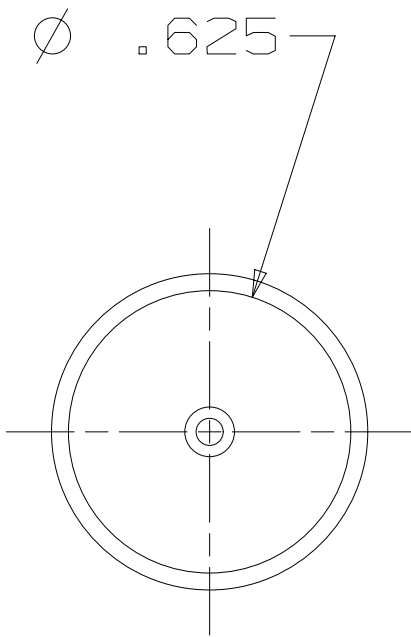
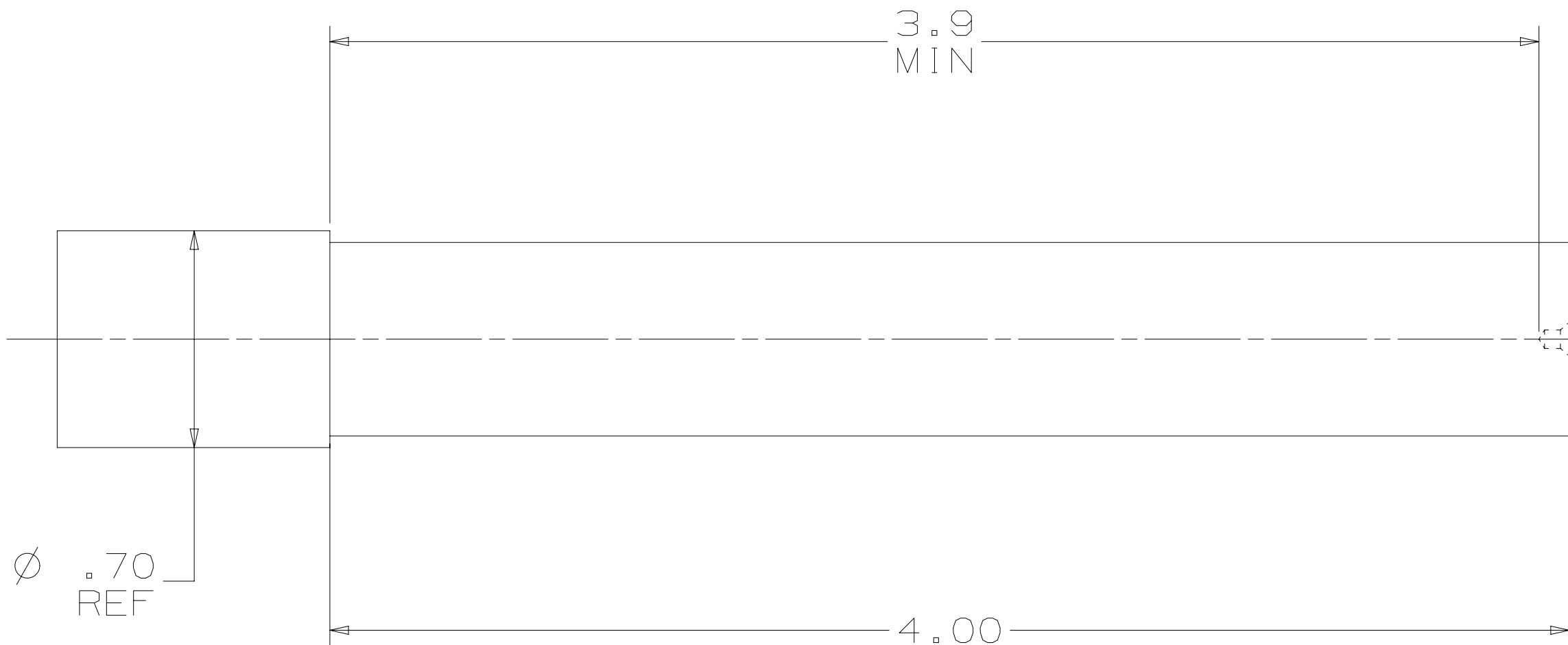
4

3

2

1

1							
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION		CN#
							CHG
							APV



DECIMALS                      TOLERANCES

1 PLACE..... ±.030                      ANGULAR  
2 PLACE..... ±.010                      ±0° 30'

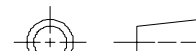
3 PLACE..... ±.005                      FRACTIONS  
4 PLACE..... ±.0005                      ±1/16

UNLESS OTHERWISE SPECIFIED

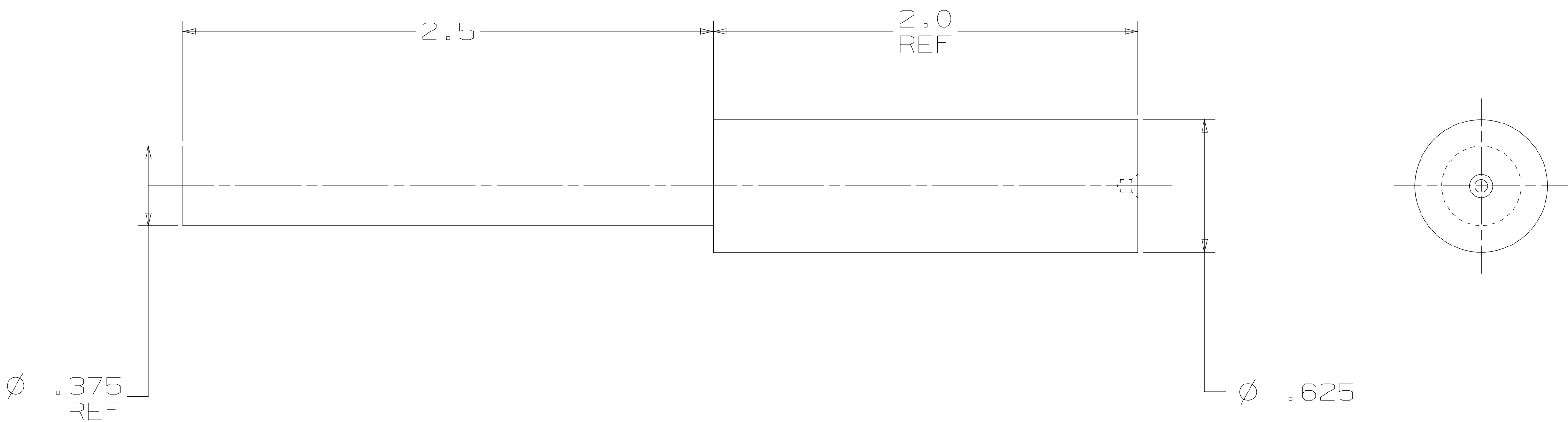
BREAK ALL SHARP EDGES

MATERIAL:

IP30  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE					
USAGE:				FOCUS: HDPE MANUFACTURING			
ARMY - FSP		THIRD ANGLE PROJECTION					
		PART NAME		SHPBC			
DRAWN BY		DATE		DWG NO.			
B.T.		11/3/11		SHPBC_IP30_DWG			
CHECKED BY				PART NO.			
R.Z.		11/3/11					
RELEASED BY		UNITS		SCALE		DWG LEVEL	
		INCHES		N/A		100	
				SIZE		REV	
				C			
						SHEET 1 of 1	

1						
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#



DECIMALS                      TOLERANCES

1 PLACE..... ±.030                      ANGULAR  
2 PLACE..... ±.010                      ±0° 30'

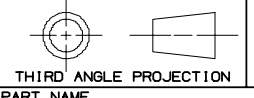
3 PLACE..... ±.005                      FRACTIONS  
4 PLACE..... ±.0005                      ±1/16

UNLESS OTHERWISE SPECIFIED

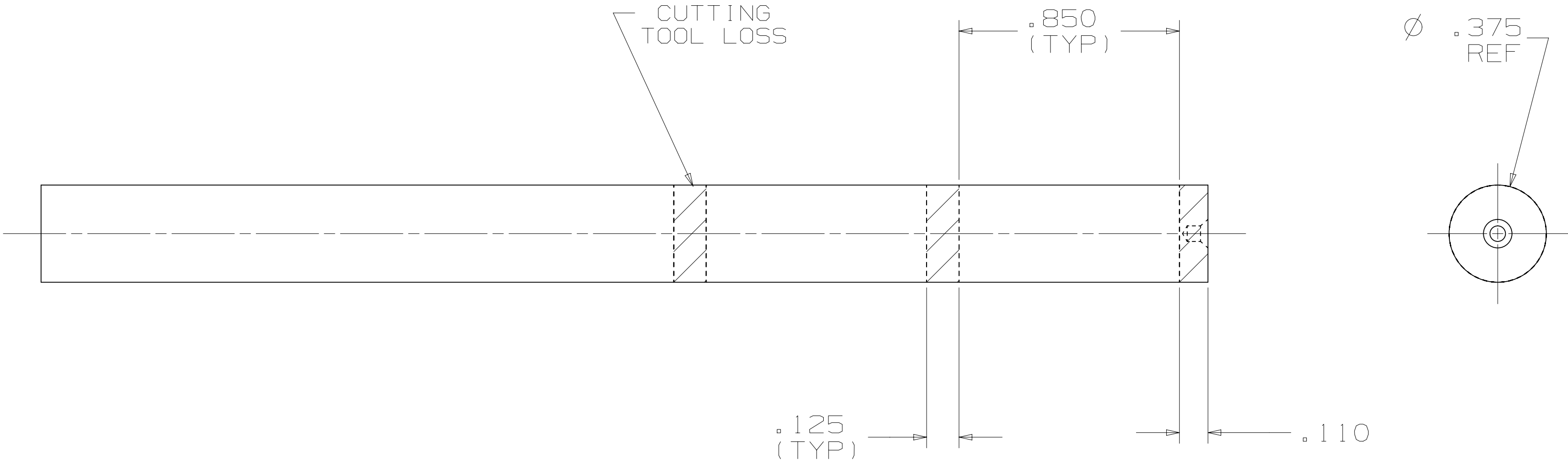
BREAK ALL SHARP EDGES

MATERIAL:

IP40  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>			
USAGE: ARMY - FSP		 THIRD ANGLE PROJECTION		<b>FOCUS CODE</b> MANUFACTURING	
DRAWN BY B.T.		DATE 11/3/11		PART NAME SHPBC	
CHECKED BY R.Z.		DATE 11/3/11		DWG NO. SHPBC_IP40_DWG	
RELEASED BY		UNITS INCHES		SCALE N/A	SIZE C
				DWG LEVEL 100	REV
				SHEET 1 of 1	

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS                      TOLERANCES

1 PLACE..... ±.030                      ANGULAR  
2 PLACE..... ±.010                      ±0° 30'

3 PLACE..... ±.005                      FRACTIONS  
4 PLACE..... ±.0005                      ±1/16

UNLESS OTHERWISE SPECIFIED

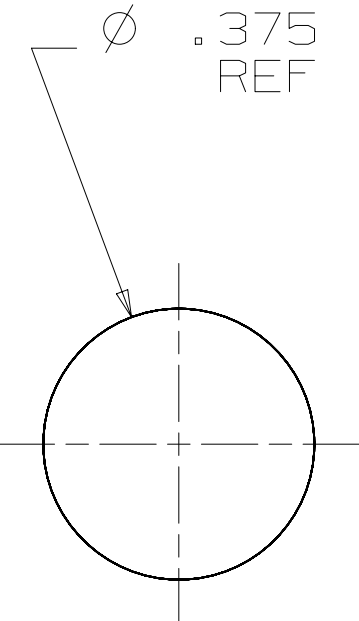
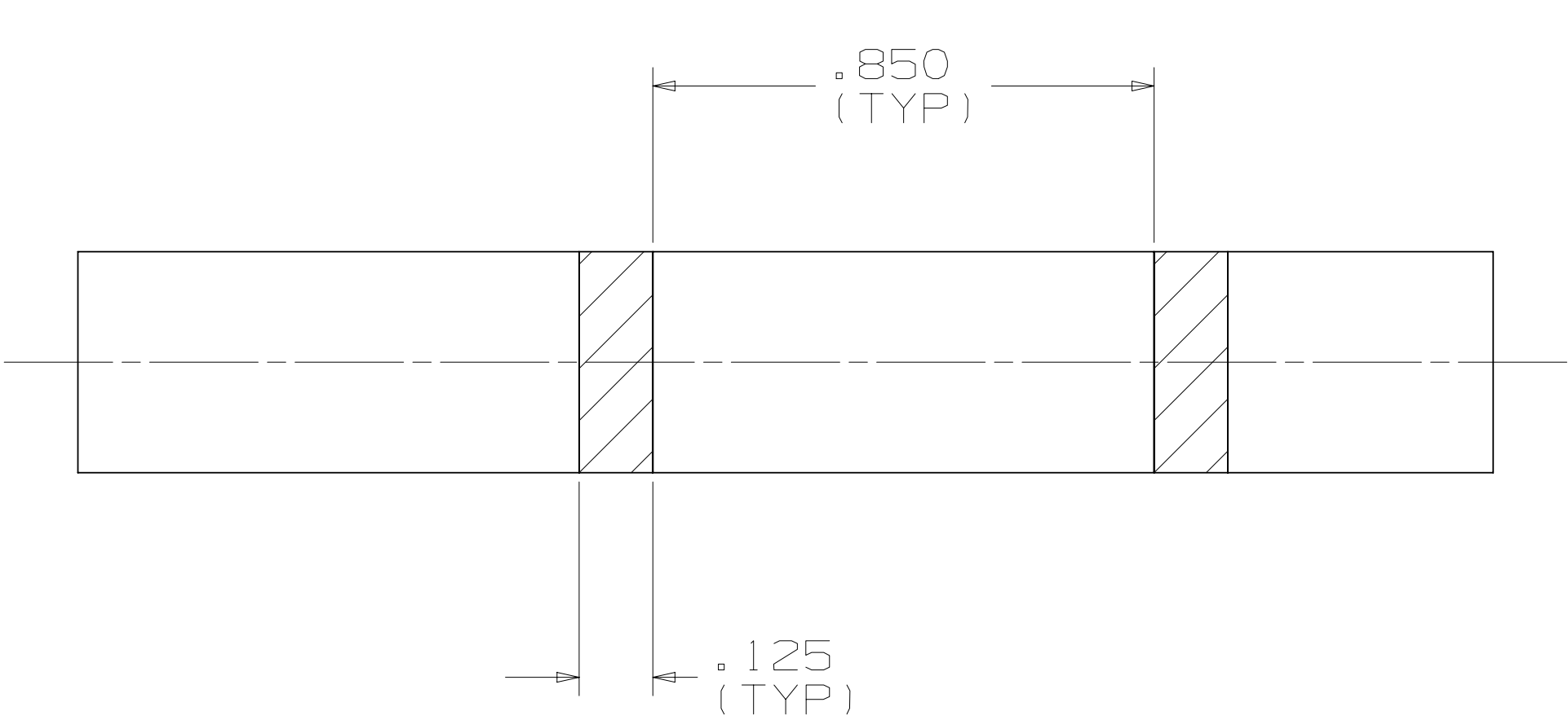
BREAK ALL SHARP EDGES

MATERIAL:

IP50  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>					
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING			
ARMY - FSP		PART NAME SHPBC					
DRAWN BY B.T.	DATE 11/3/11	DWG NO. SHPBC_IP50_DWG					
CHECKED BY R.Z.	11/3/11	PART NO.					
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1	

1							
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION		CN#
							CHG
							APV



DECIMALS TOLERANCES

1 PLACE..... ±.030  
2 PLACE..... ±.010  
3 PLACE..... ±.005  
4 PLACE..... ±.0005

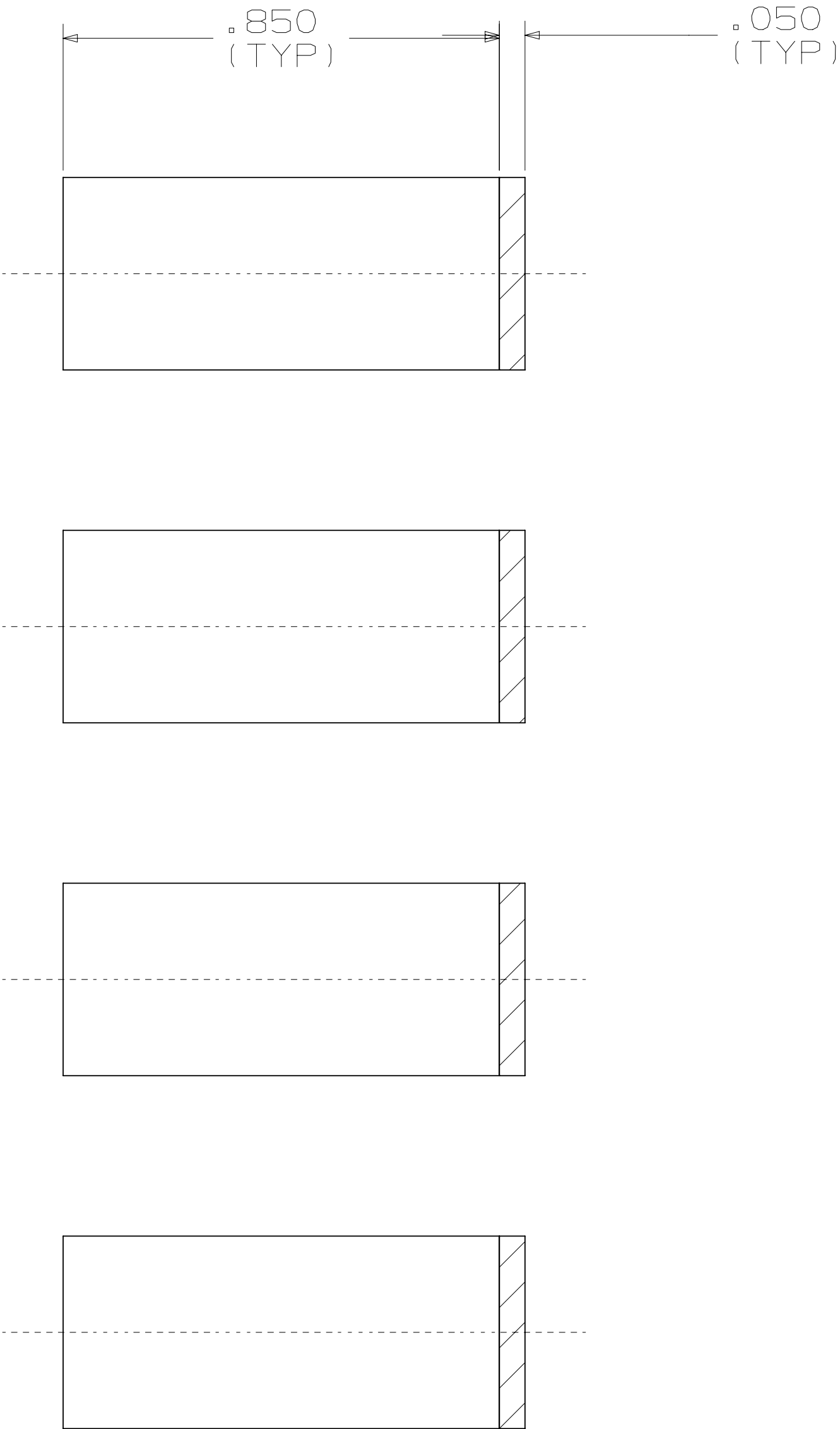
ANGULAR  
±0° 30'  
FRACTIONS  
±1/16

UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL:

IP60  
DWG

UG CHANGE RESTRICTED				DO NOT SCALE			
USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING			
ARMY - FSP		PART NAME		SHPBC			
DRAWN BY	B.T.	DATE	11/3/11	DWG NO.	SHPBC_IP60_DWG		
CHECKED BY	R.Z.	DATE	11/3/11	PART NO.			
RELEASED BY		UNITS	INCHES	SCALE	N/A	SIZE	C
		DWG LEVEL	100	REV		SHEET	1 of 1

1							
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION		CN#



DECIMALS		TOLERANCES		ANGULAR	
1 PLACE	±.030			±0° 30'	
2 PLACE	±.010				
3 PLACE	±.005			FRACTIONS	
4 PLACE	±.0005			± 1/64	

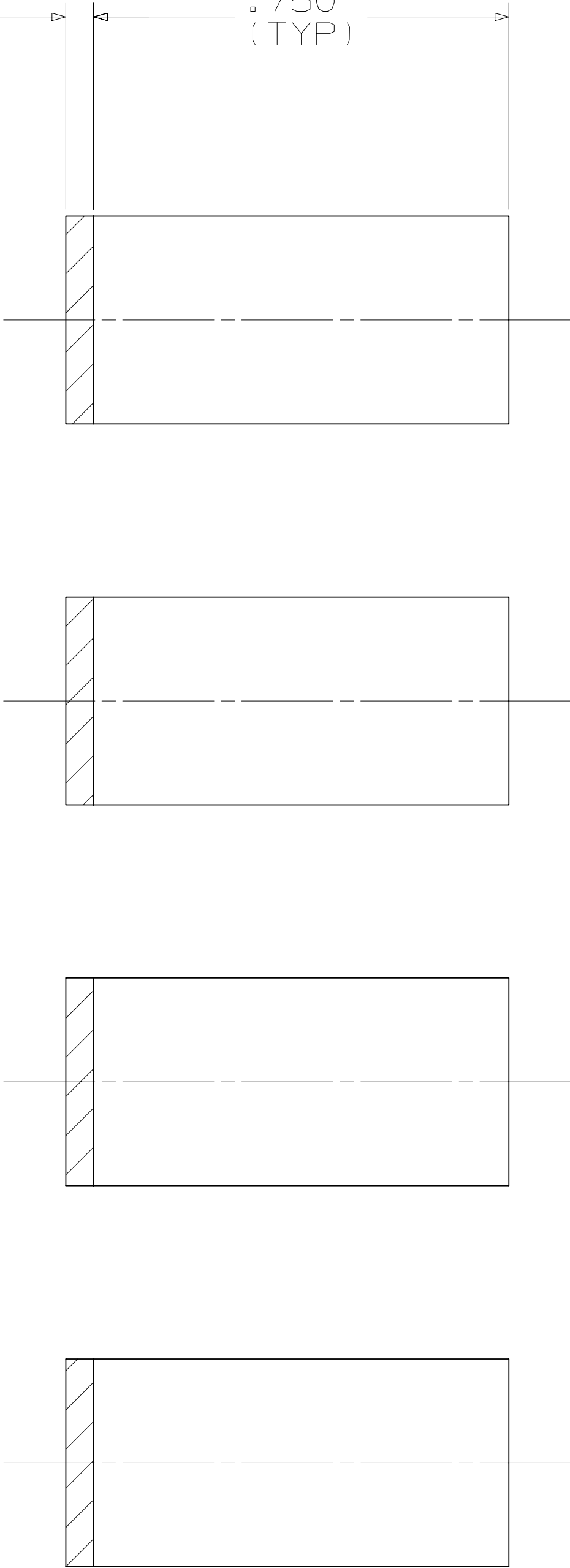
UNLESS OTHERWISE SPECIFIED  
BREAK ALL SHARP EDGES  
MATERIAL :

IP70  
DWG

UG CHANGE RESTRICTED				DO NOT SCALE			
USAGE :		THIRD ANGLE PROJECTION		FOCUS CODE			
ARMY-FSP				MANUFACTURING			
DRAWN BY		DATE		PART NAME			
B.T.		11/3/11		SHPBC			
CHECKED BY		DATE		DWG NO.			
R.Z.		11/3/11		SHPBC_IP70_DWG			
RELEASED BY		UNITS		PART NO.			
		INCHES		X			
		SCALE		SIZE		DWG LEVEL	
		N/A		C		100	
				REV		SHEET 1 of 1	

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

±.050 (TYP) ±.750 (TYP)



DECIMALS	TOLERANCES	ANGULAR
1 PLACE.....	±.030	±0° 30'
2 PLACE.....	±.010	
3 PLACE.....	±.005	FRACTIONS
4 PLACE.....	±.0005	±1/64

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL:

IP80  
DWG

UG CHANGE RESTRICTED			DO NOT SCALE					
USAGE: ARMY-FSP			THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING			
DRAWN BY B.T.			DATE 11/3/11		PART NAME SHPBC			
CHECKED BY R.Z.			DWG NO. SHPBC_IP80_DWG		PART NO. X			
RELEASED BY			UNITS INCHES		SCALE N/A	SIZE C	DWG LEVEL 100	REV X
					SHEET 1 OF 1			

**Focus: HOPE Process routing/Shop traveler**

Customer: <b>Southwest Research Institute</b>		
Street Address:		
City State Zip:		
Stock: <b>3/4 x 3/4 x 4 1/2 coupon (8)</b>		
Part Number: <b>SHPB Tensile (5083/6061)</b>		
Description: <b>Johnson-Cook test specimen</b>		
Revision:		
Op No	Labor Code	Operation Description
		See 'Strips' Process Sheet for initial specimen extraction operations.
		Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT,
10		Confirm that all material blocks are marked "6061-W"
20	Mill	Square mill end, round (circular interpolate) end to 0.70 dia x 0.88 and center drill
30	Laser	Mark end "61W-#" (where # = 1 thru 8)
40	Mill	Mill end square, center drill, rough contour turn, final contour turn, single point thread, and finally turn thread OD to .490 dia
50	laser marker	Mark 2 Places (ends) "61W-#" (where # = 1 thru 8)
60		Individually bag each part
70		Label Bags
80		Polish Longitudinally
90		Cut-off to final length 2.235



4

3

2

1

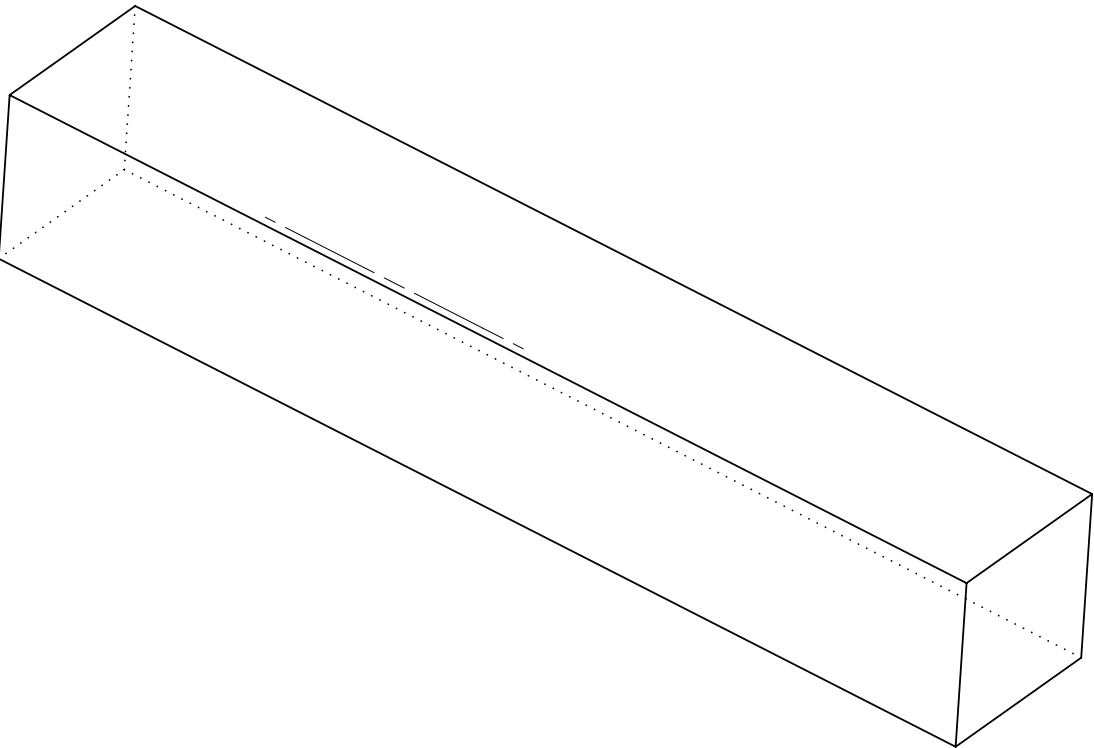
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

C

C

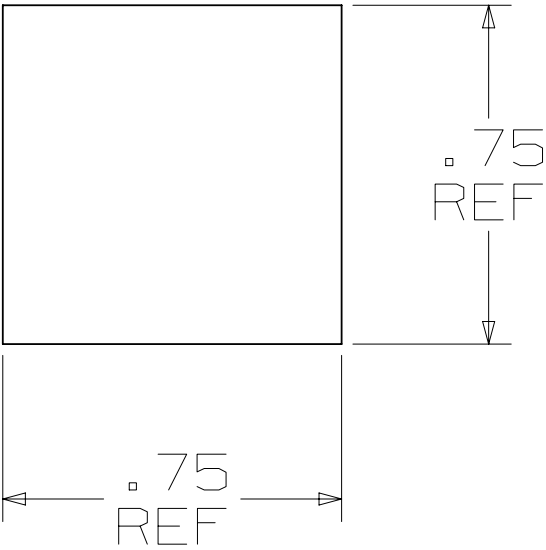
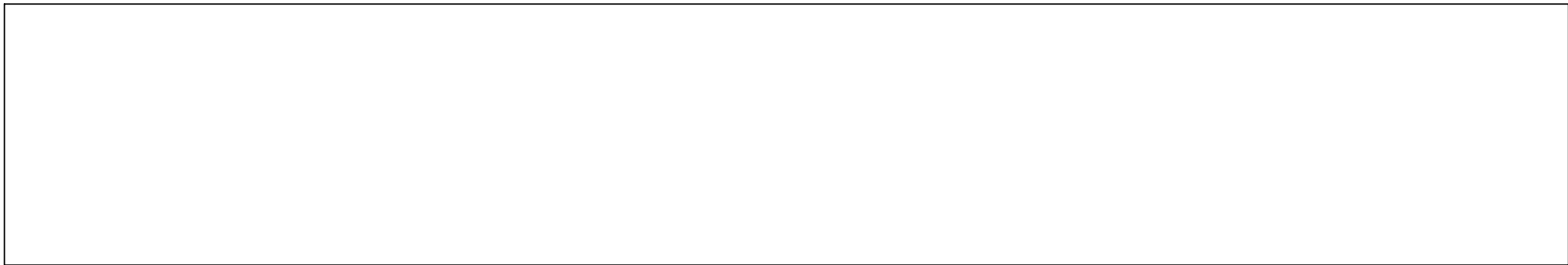


MMMM - X - TOP - NN



B

B



A

A

IP10  
DWG

DECIMALS                      TOLERANCES                      ANGULAR

1 PLACE..... ±.030                      ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.003                      FRACTIONS                      ±1/64

4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

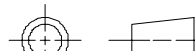
MATERIAL :

4

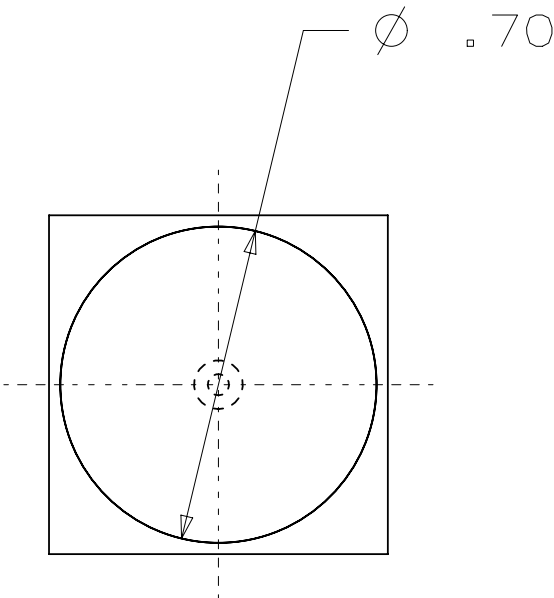
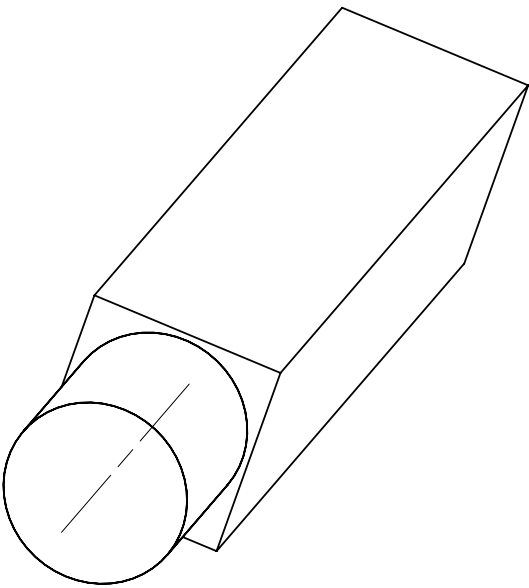
3

2

1

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>				
USAGE:  ARMY - FSP				FOCUS: CODE MANUFACTURING		
		THIRD ANGLE PROJECTION				
		PART NAME SHPB TENSILE				
DRAWN BY B.T.		DATE 10/6/11		DWG NO. SHPB_TENSILE_IP10_DWG		
CHECKED BY R.Z.		10/6/11		PART NO.		
RELEASED BY				SCALE N/A	SIZE C	DWG LEVEL 100
					REV	SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS                      TOLERANCES                      ANGULAR

1 PLACE..... ±.030                      ±0° 30 '

2 PLACE..... ±.010                      FRACTIONS


3 PLACE..... ±.003                      ±1/64

4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP20  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>			
USAGE:  ARMY FSP				<b>FOCUS CODE</b> <b>MANUFACTURING</b>	
		THIRD ANGLE PROJECTION			
PART NAME		SHPB TENSILE			
DRAWN BY	B.T.	DATE	10/6/11		
DWG NO.		SHPB_TENSILE_IP20_DWG			
CHECKED BY	R.Z.	10/6/11	PART NO.		
RELEASED BY		SCALE	SIZE	DWG LEVEL	REV
		N/A	C	100	
		SHEET 1 of 1			

4

3

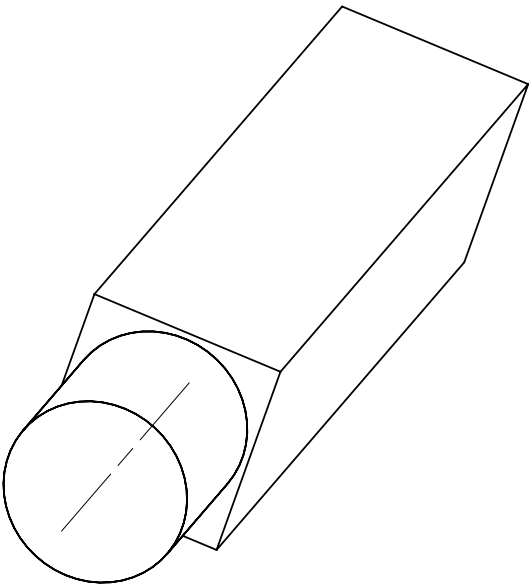
2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

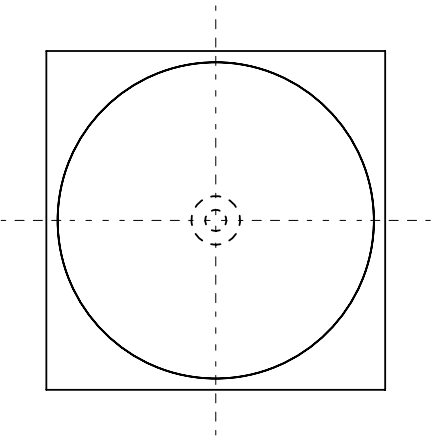
C

C



B

B



A

A

IP30  
DWG

DECIMALS                      TOLERANCES                      ANGULAR

1 PLACE..... ±.030                      ±0° 30 '


2 PLACE..... ±.010                      FRACTIONS                      ±1/64

3 PLACE..... ±.003

4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

MATERIAL :

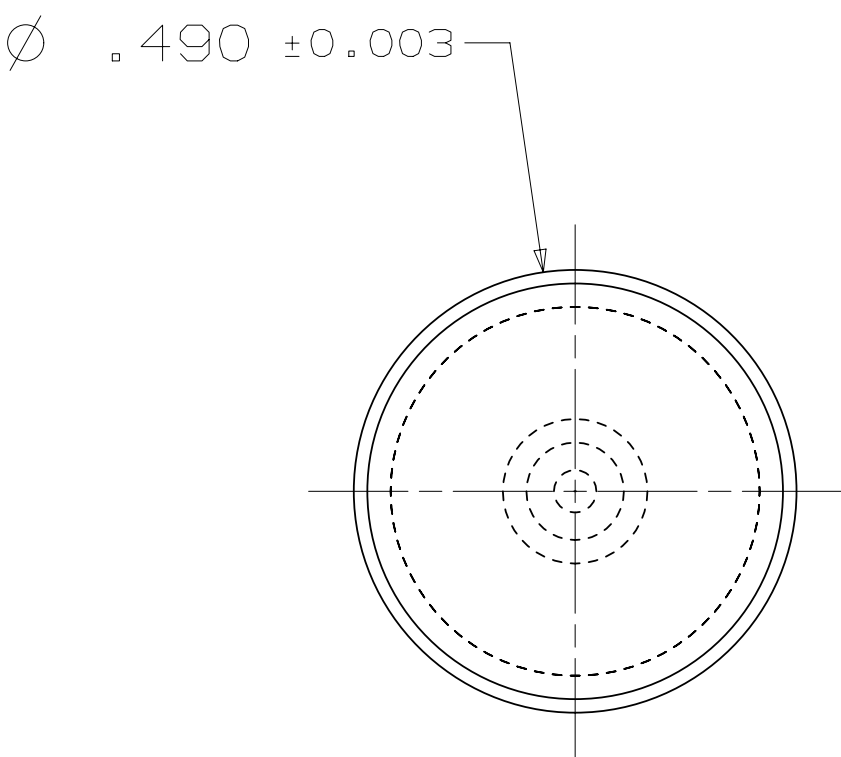
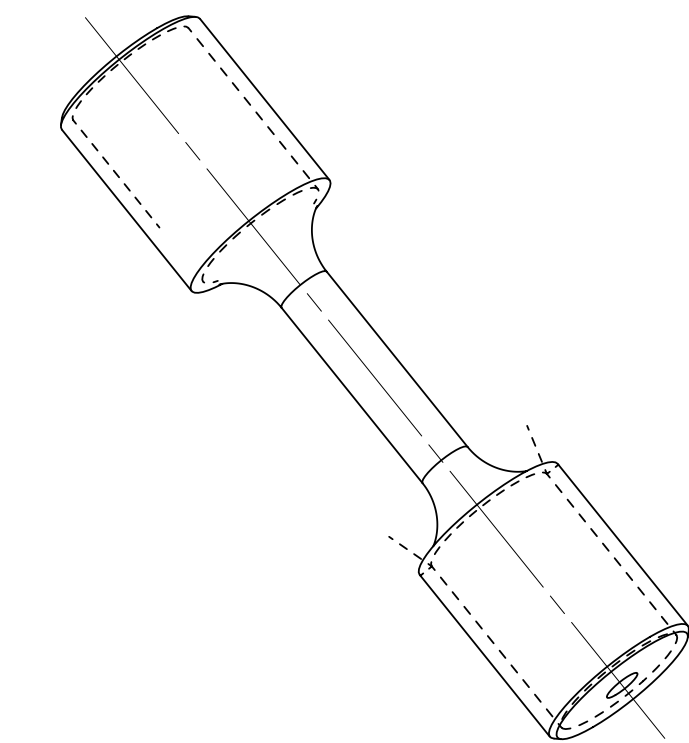
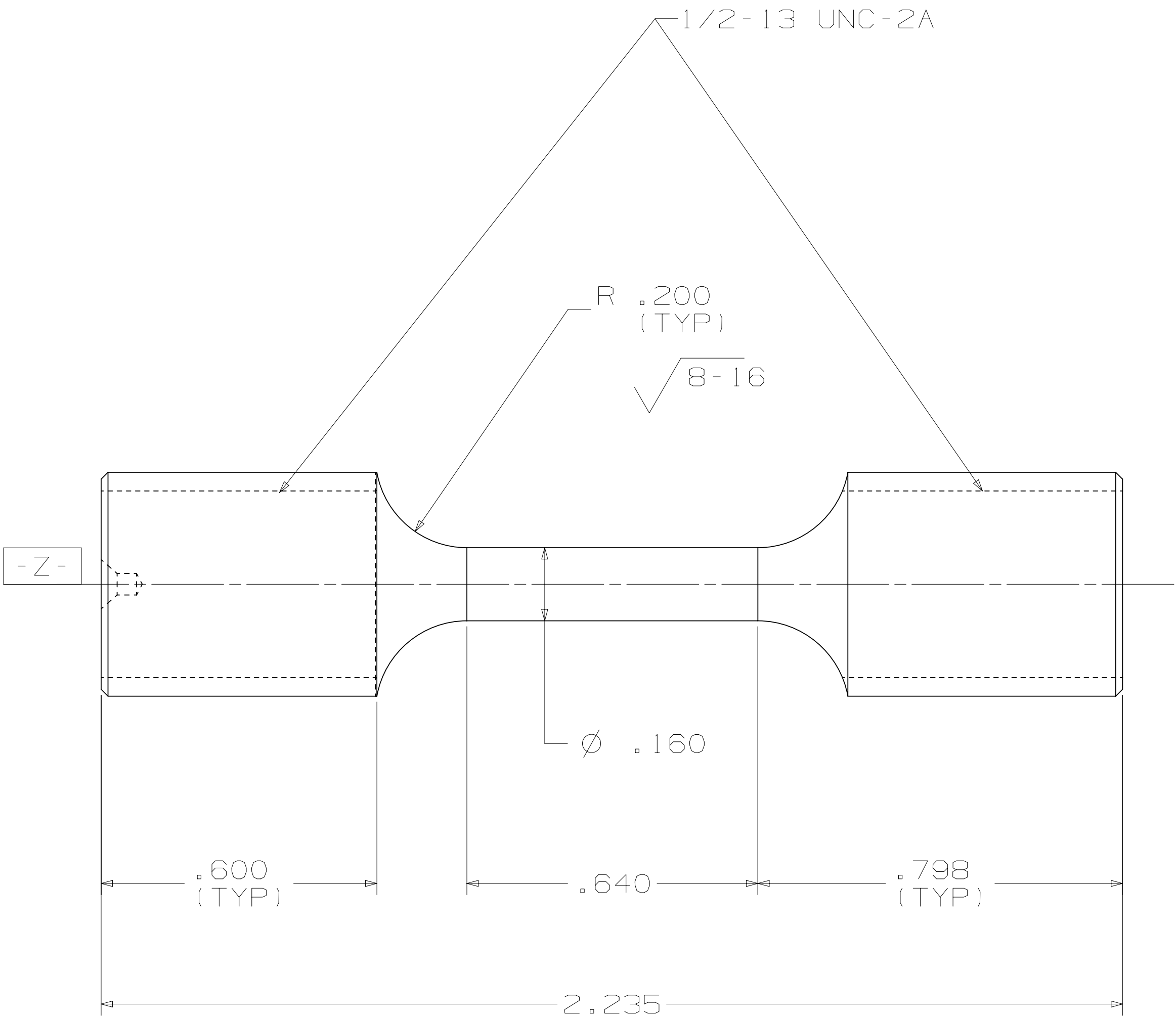
<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>			
USAGE:  ARMY FSP				<b>FOCUS CODE</b> <b>MANUFACTURING</b>	
		THIRD ANGLE PROJECTION			
PART NAME		SHPB TENSILE			
DRAWN BY	B.T.	DATE	10/6/11		
DWG NO.		SHPB_TENSILE_IP30_DWG			
CHECKED BY	R.Z.	10/6/11	PART NO.		
RELEASED BY		SCALE	SIZE	DWG LEVEL	REV
		N/A	C	100	
		SHEET 1 of 1			

4

3

2

1



TOLERANCES (INCH)  
DECIMALS

- 1 PLACE.....  $\pm .030$
- 2 PLACE.....  $\pm .010$
- 3 PLACE.....  $\pm .005$
- 4 PLACE.....  $\pm .0005$


UNLESS OTHERWISE SPECIFIED

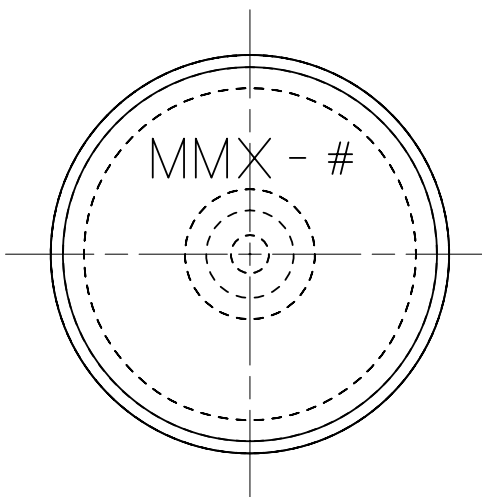
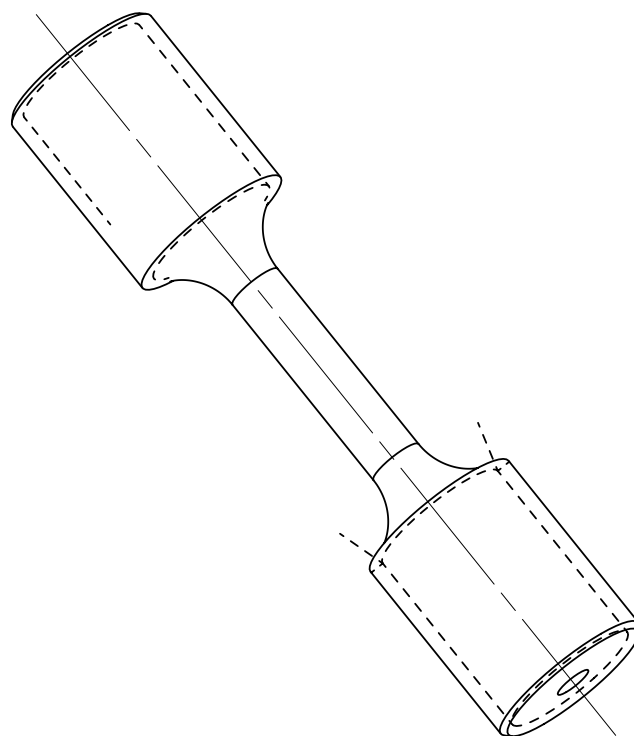
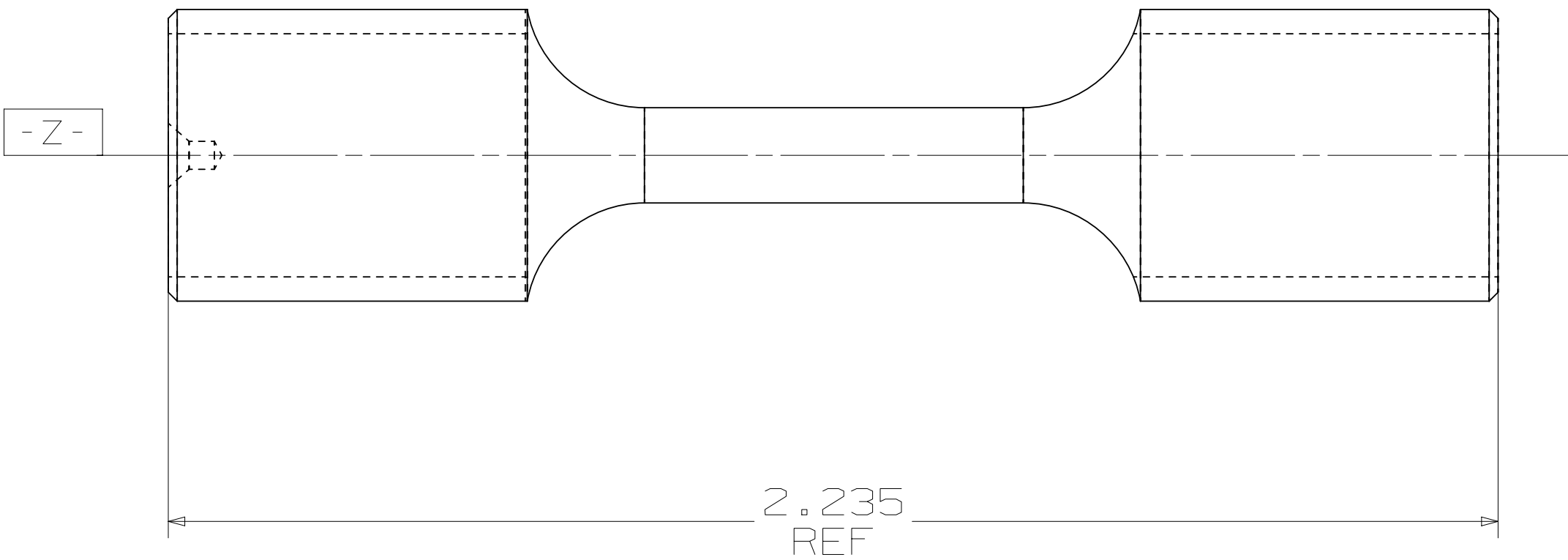
MATERIAL :

ANGULAR  
 $\pm 0^{\circ} 30'$

FRACTIONS  
 $\pm 1/64$

IP40  
DWG

UG CHANGE RESTRICTED		DO NOT SCALE											
USAGE:				FOCUS CODE									
ARMY FSP				MANUFACTURING									
		THIRD ANGLE PROJECTION											
		PART NAME		SHPB TENSILE									
DRAWN BY B.T.		DATE 10/7/11		DWG NO.		SHPB_TENSILE_IP40-DWG							
CHECKED BY R.Z.		DATE 10/7/11		PART NO.									
RELEASED BY				SCALE N/A		SIZE C		DWG LEVEL 100		REV		SHEET 1 of 1	



TOLERANCES (INCH)  
DECIMALS

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005


UNLESS OTHERWISE SPECIFIED

MATERIAL:

ANGULAR  
±0° 30'

FRACTIONS  
±1/64

IP50  
DWG

<b>UG</b> CHANGE RESTRICTED		<b>DO NOT SCALE</b>					
USAGE:  ARMY FSP				FOCUS: <b>CODE</b> <b>MANUFACTURING</b>			
		THIRD ANGLE PROJECTION					
		PART NAME SHPB TENSILE					
DRAWN BY B.T.	DATE 10/7/11	DWG NO. SHPB_TENSILE_IP50_DWG					
CHECKED BY R.Z.	10/7/11	PART NO.					
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1	